POWER

Volume 54 New York, December 20, 1921 *Number* 25

The A. S. M. E.

FORTY-TWO years ago last February about forty gentlemen, some of them "coming from as far west as Ohio for the special purpose," gathered at the office of the *American Machinist* in New York, and organized The American Society of Mechanical Engineers.

They gathered in response to an invitation issued by Prof. John E. Sweet, Prof. R. H. Thurston and Alexander L. Holley.

John Edson Sweet started life as a small-town carpenter, architect and mechanic. He was so plain that, much to the mortification of his good wife, he carried his lunch in a dinner pail after he had been called as director of shops at Sibley College, and lovable beyond my power to tell.

Dr. Robert Henry Thurston was the head of the Mechanical Department of Stevens Institute of Technology and afterward of Sibley College, over which Dean Dexter S. Kimball, the newly elected president of the Society, now presides. His eminence in the profession is too well recognized for comment.

Alexander Lyman Holley was associated with Corliss and with Zerah Colburn, becoming editor and owner of Colburn's *Advocate*. His writings in this and other capacities are notable contributions to the literature, especially, of railway engineering. He became the leading engineer of his time of the steel industries.

I wonder if these men or the men whom they called together had any conception of the structure of which they were laying the corner stone. I wonder what reception one would have got who had had the vision and temerity to predict that in two score years it would have a membership of fifteen thousand and a leading position among the professional engineering societies of the world.

There were those who referred to it in derision as "a guild of glorified mechanics." There are still those to whom "mechanics" suggests no more than a cold chisel, a hammer and a bastard file.

Dwelshauvers-Dery, among the first to advocate the study of steam engineering in a university, was met in his attempts to obtain an engine and apparatus for his laboratory at Liége with the statement that he might as well put in a hothouse and teach farming.

The underlying theme of the meeting of the Society reported in this issue was the Elimination of Waste in Industry, in which power-plant problems played a leading part. On the opening day, without any blazon of trumpets, without any flights of oratory or the handing out of Hopes, over 850 earnest engineers were working on the practical details of the problem. They came from Canada and from the Gulf, from the Atlantic and the Pacific seaboards. There was but one state in the Union that was not represented.

The activities of the Society comprise everything that concerns mechanical engineering and much that concerns engineering in general. It is actuated by the desire to magnify the service of the engineering profession to the world, and in that service the profession, the Society and its members will find the most direct road to grateful recognition.

A.S.M.E. Holds Annual Meeting

Power Plant Subjects Predominate—Heat Balance and Fuel Waste Prove Live Topics—Movies Show Stoker Operation

THE increasing attention that has been given power problems in the last few years by the American Society of Mechanical Engineers was emphasized at its recent annual meeting, with four papers on heat balance, four on fuel waste and others as directly related to the production of power. The affair drew a total of 1,854 engineers from all parts of the country for a group of sessions lasting five days, Dec. 5-9, and was held in the Engineering Societies Building, New York City.

The convention was formally opened by President Carman on Monday afternoon, Dec. 5, when he called to order the leading session on Elimination of Waste in Industry, turning over the meeting to L. P. Alford, chairman of the Management Division.

Administrative Efforts Criticized

Fred. J. Miller, past president of the society, was the first speaker. His principal recommendation was to treat employees as human beings, without trying to perfect a machine-like organization to wring greater efficiency out of them. He attributed the real cause of manufacturing waste to wrong administrative efforts, for the correction of which he held owners and managers responsible. He was extremely critical of financiers and went so far as to say that limitations put upon production by the workers were insignificant compared with those resulting from financial juggling, avoidably irregular employment, unnecessary tying up of capital, and other effects of incompetent and dishonest direction.

Prof. Breckenridge, of Yale, followed with a talk on the Superpower report, pointing out the possible savings that would result from carrying the plan into effect. He explained that the facts are before us in the report, that the next step is to study them, then to secure the necessary legislation and finally to finance the project.

Ernest F. duBrul, of Cincinnati, general manager of the National Machine Tool Builders Association, did not hesitate to arraign management for the greater part of our national waste, but, in contrast with Mr. Miller, felt that the trouble was not so much with inefficient administrative methods as with plain business stupidity and lack of foresight.

W. S. Murray, who had charge of the Superpower Survey, described his recent work in a brief address and indicated its scope and possibilities. Henry Flood, Jr., who was associated with Mr. Murray as engineer-secretary of the Survey, also spoke briefly and pointed out the great saving in capital contemplated under the Superpower scheme through the interconnection of many plants and the resulting use of a higher load factor, which would, of course, make possible the production of more power per dollar invested.

J. Parke Channing, who was the chairman of the Committee on the Elimination of Waste, declared that management is responsible for about 50 per cent of our industrial waste, but added that all managers are not engineers. He felt this to be one of the chief causes of inefficiency and made a plea for more technically trained men in place of the financiers who now make up so large a number among the directors of industry. He emphasized the point, however, that before engineers can advance to this work they must fit themselves for it by a study of economics and human relations.

The Presidential Address

The presidential address and reception took place on Tuesday evening. The retiring president, Edwin S. Carman, pointed out that for forty years the society had applied itself with the greatest success to problems of a technical, purely mechanical and material nature. Now, without sacrificing the results of its past efforts, the organization should enter upon a broader field, in keeping with that admirable clause of the Constitution of the Federated American Engineering Societies, which reads "Engineering is the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and of organizing and directing human activities in connection therewith." It is the second part of this clause that President Carman impressed especially upon his hearers, thereby pointing out to his successor the course that he thinks would be best to follow in guiding the organization to success.

There followed the formal presentation of honorary membership to Henry R. Towne, a past president of the society and a member since 1882. He is well known by his contributions to engineering literature and by his work as a manufacturer, being the directing head of the Yale & Towne Manufacturing Co. Nathanial G. Herreshoff also has been awarded honorary membership, and it was to be formally bestowed upon him the same evening, but he was unfortunately unable to be present.

President-elect Kimball was introduced and spoke a few words of appreciation of the honor that had been accorded him as head of the society for the coming year. He mentioned that this honor was particularly great to him because of the fact that many of those who had been foremost in the organization of the A. S. M. E. had likewise been among the pioneers in the establishment of Cornell University, with which he has been associated for many years.

Business Meeting

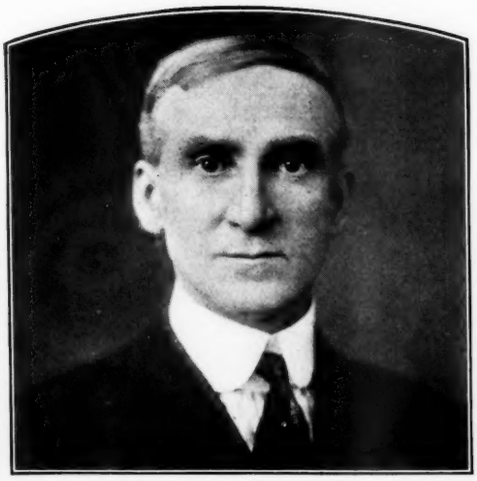
The business meeting, which lasted all day Wednesday, was fairly well attended and brought forth much discussion, most of which centered upon the proposed new constitution.

The report of the Finance Committee was especially interesting, revealing the magnitude of the society's operations. The gross receipts from all sources for the fiscal year ended Sept. 30, 1921, were $497,401.18—practically half a million dollars a year! The excess of receipts over expenditures was $17,982.08, which is in pleasing contrast with the condition of many other societies.

Reports of the standing committees were accepted with a vote of thanks to Secretary Rice for his efficient and businesslike conduct of the society's affairs.

Two pairs of amendments to the constitution were then taken up, one of which would give junior members the right to vote and hold office, and the other of which

NEW OFFICERS *of the* A.S.M.E.



DEXTER S. KIMBALL
President

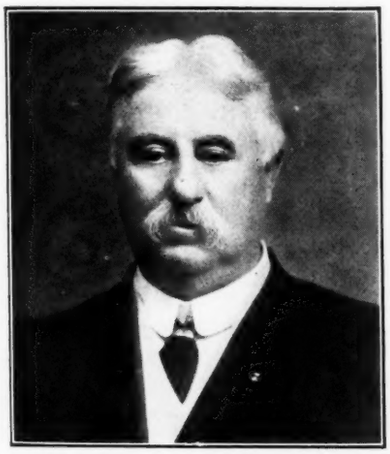
Mr. Kimball is vice-president of the Federated American Engineering Societies and dean of the College of Engineering at Cornell University. He joined the society in 1900 and has served on several important committees, becoming manager in 1919. He has contributed widely to the technical press and has written a number of books on industrial problems. Dean Kimball has become especially prominent during the last year as a result of his enthusiastic championship of the Federated American Engineering Societies.

ROBERT SIBLEY
Vice-President

Mr. Sibley is president of the McGraw-Hill Company of California, and editor of "Journal of Electricity and Western Industry."

LOUIS E. STROTHMAN
Vice-President

Mr. Strothman (formerly manager), has served since 1918 as chairman of the Power Test Code Committee on Reciprocating Pumps.

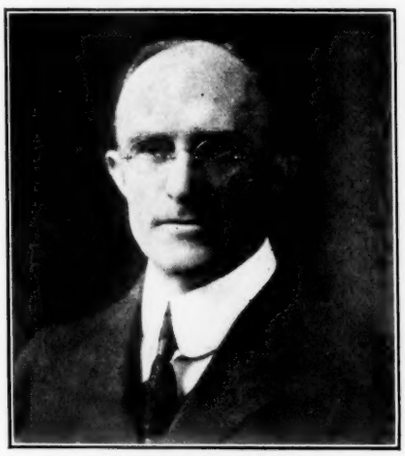


MAJOR WILLIAM H. WILEY
Treasurer

Major Wiley has been continuously re-elected for 37 years. He fought in the Civil War and served in Congress, and since 1876 has been a publisher of scientific works.

COLONEL EDWARD A. DEEDS
Vice-President

Colonel Deeds had a big part in war work in carrying out air-craft production. He is now president of the Domestic Engineering Co. and the Smith Gas Engineering Company



CALVIN W. RICE
Permanent Secretary

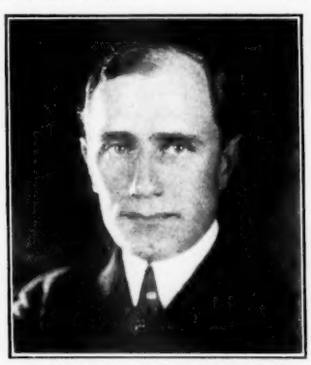
Mr. Rice is a familiar figure at conventions, having been secretary since 1906. He has for years worked enthusiastically for a more public spirited consciousness among engineers.

SHERWOOD F. JETER
Manager

Mr. Jeter has been active in Boiler Code work, and is well known as the chief engineer of the Hartford Steam Boiler Inspection and Insurance Company

HOLLIS P. PORTER
Manager

Mr. Porter was the first chairman of the Mid-Continent Section and is on American Engineering Council. He has charge of the research and engineering for the Gulf Oil Corp.



HORACE P. LIVERSIDGE
Manager

Mr. Liversidge is also a prominent worker in the A. I. E. E., the A. I. S. E. E., the N. E. L. A. He is assistant chief engineer of the Philadelphia Electric Company.

WALTER S. FINLAY, Jr.
Manager

Mr. Finlay is chairman of the Metropolitan Section and vice-president of the American Water Works and Electric Co. He was for ten years with the Interborough, in New York.

would simply make amendments of the constitution easier and less tedious. Both were referred to letter ballot, and there is little doubt that they will be approved.

A number of prizes were awarded, the most important of which was the A. S. M. E. medal award. This had been assigned to Hjalmer G. Carlson, of Worcester, Mass., covering his invention for the production of booster casings. Other awards were as follows: Junior prize, to S. Logan Kerr, of the I. P. Morris Department of Cramp & Sons, for his paper on Moody Ejector Turbines; student prizes, to Karl H. White, of the University of Kansas, for a paper on "Forces in Rotary Motors," and to Messrs. Richard H. Morris and Albert J. R. Houston, jointly, of the University of California, for a paper on "A Report Upon an Investigation of the Herschel Type of Improved Weir"; life membership, to Forrest Nagler, of the Allis-Chalmers Manufacturing Co., for a paper on "A New Type of Hydraulic Turbine." The presentation of these prizes was in the hands of Dr. Ira N. Hollis, past president of the society.

The most important work of the business meeting was consideration of the proposed new constitution. which is being simplified by removing from it everything not of a fundamental nature and putting the excluded provisions into the by-laws.

Movies Show What Goes on Inside a Furnace

One of the most talked-of features of the convention, because of its unique nature, was R. Sanford Riley's motion picture of stoker operation, which enabled the audience to see, with great clearness and comfort, the process of combustion going on in a furnace. The picture was taken slowly and run off fast, so that it showed in two minutes all the changes that took place during four hours of stoker operation, beginning with a banked fire and speeding up to a high rating. The method used in taking this remarkable movie will be detailed in an early issue.

Two hearings were held under the direction of the Boiler Code Committee. One was on a group of welding codes that are to form a part of the proposed pressure-vessel section of the Boiler Code. The hearing, which lasted all day Monday, brought out considerable information that will be embodied in the new section early in 1922. A further hearing on the subject will doubtless be held some time later.

At the other hearing, on Tuesday morning, the proposed code for miniature boilers was taken up. Work on this matter is much further advanced than on the pressure-vessel rules, and the code will probably be issued without further hearings, although it may first be sent out to interested parties for comment.

Quantity production and early specialization are the two outstanding faults of our present methods of engineering education, according to a number of speakers in the session devoted to "Professional Engineering Education for the Industries." Professor Christie, of Johns Hopkins University, deplored the tendency of certain colleges to increase the size of classes and run them on the factory production idea. Dean Kimball, of Cornell University, and president-elect of the society, stressed the importance of developing in the student the engineering habit of thinking, rather than giving him specialized knowledge, which he can obtain better after graduation.

The Research Conference was held Thursday morning under the direction of Prof. Arthur M. Greene, chairman of the research committee, and resulted in the formation of an advisory committee, of about twenty-five members, which will co-operate in every way possible with the Engineering Division of the National Research Council.

The foregoing covers briefly the general features of the convention. Space does not permit a fuller discussion of them, because there is so much more to tell of the many papers that apply directly to the problems of the power plant. Abstracts of these papers and summaries of the discussion on each follow.

Heat-Balance System for Hell Gate Station*

By J. H. Lawrence and W. M. Keenan

THE Hell Gate Station of the United Electric Light and Power Co., now being built in New York City, will have an ultimate capacity of 280,000 kw., consisting of eight 35,000-kw. turbo-generators. The initial generating installation will consist of two 25-cycle General Electric single-cylinder units and two 60-cycle Westinghouse double-cylinder units. The station will be operated as four independent groups, each consisting of one 60-cycle, one 25-cycle unit, one house alternator and six boilers, although provisions have been made for interconnecting the various groups electrically and mechanically.

All auxiliaries in this station are to be motor-driven, with the exception of one boiler-feed pump for each group, one fire pump and one of two exciters for each house alternator. The house turbines will be non-condensing machines, running at 3,600 r.p.m. Any of the station auxiliaries, excepting the motors on the coal towers, cranes and skip hoist, may be operated from either the bus supplied by the main units or the house-alternator bus.

The condensate after leaving the condensers goes through two closed heaters, where it is heated to about 150 deg. F. and then enters an open heater, where it is raised to 210 deg. F. The condensate is then pumped by the boiler-feed pumps direct to the boilers. Thermostatically controlled valves equalize the load on the two closed heaters. The closed heaters are supplied with steam at about 6.5 lb. absolute pressure bled from the lower stages of the main turbines. Fresh water obtained from the surge tank is used for the oil coolers and air-ejector condensers and discharges to the inlet of the closed heaters in order to conserve the heat from those different sources.

The house turbine exhausts at 1 lb. back pressure directly to the open heater. The exhaust from the high-pressure packing of the General Electric unit, approximately 4,000 lb. of steam per hour, also flows directly into the open heater.

In order to insure a sufficient supply of steam to the open heaters at all loads on the house alternator, steam is bled from intermediate stages of the main turbines through pressure-control valves so adjusted as to automatically maintain 1 lb. back pressure in the open heaters. An auxiliary control board is provided by which one man will supervise all the station auxiliaries.

*A complete story is in preparation on this station for publication in an early issue in *Power*. As Hell Gate station was not in full operation at the time this paper went to press, operating figures were not available on the heat-balance system, but it was thought that a description of the system to be employed to obtain the heat balance would be of interest.

Auxiliary System and Heat Balance at the Delaware Station*

By E. L. Hopping

IN WORKING out the auxiliary system and heat balance for the Delaware station of the Philadelphia Electric Co., the factor of reliability of service was considered of prime importance, and of somewhat greater value than that of heat economy. It has always been considered by this company that the small comparative cost of duplicating the main-generating-unit auxiliaries is fully warranted in view of the resulting ability to keep a large unit on the line in case of failure of any one of the different auxiliaries connected with the unit.

Knowing the amount of heat required under varying vacuum and load conditions, it remains to select such auxiliaries to be steam-driven as would furnish the required heat through their exhaust. It was found possible to obtain this result by installing turbine drive on one of each of the duplicate auxiliary pumps connected with the main generating units, together with turbine drive on boiler-feed pumps and on one house pump. It was found necessary, however, at times of heavy load and high vacuum, to supply a certain additional amount of heat, which is obtained by bleeding the main turbine at the eleventh stage.

On each of the main units one of the two circulating pumps is installed with a duplex (steam and motor) drive. By use of this type of drive a flexible unit is available, which, by varying the load on the turbine drive, will supply the required heat variation for maintaining a practically constant feed-water temperature.

*See May 24, 1921, issue of *Power* for detailed description of this station.

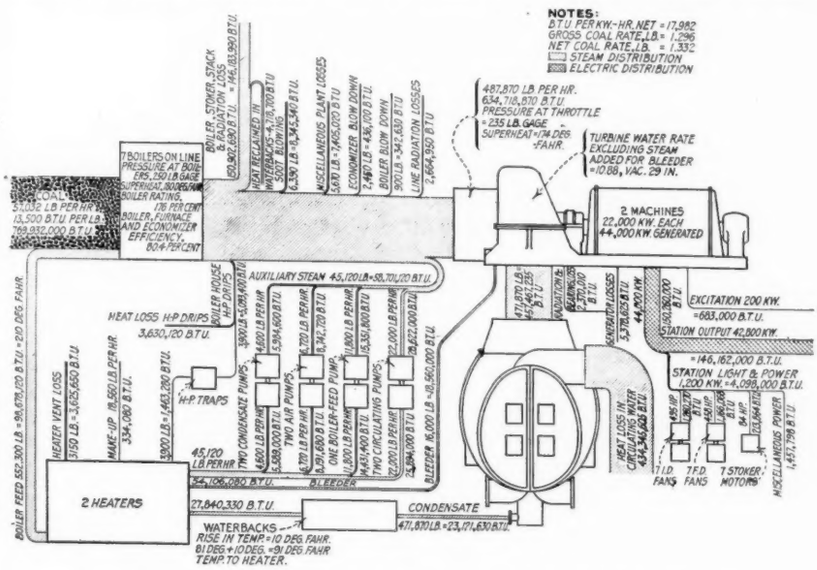

NOTES:
B.T.U. PER KW.-HR. NET = 17,982
GROSS COAL RATE, LB. = 1.296
NET COAL RATE, LB. = 1.332
STEAM DISTRIBUTION
ELECTRIC DISTRIBUTION
487,870 LB. PER HR.
634,710,810 B.T.U.
PRESSURE AT THROTTLE = 235 LB. GAGE
SUPERHEAT = 174 DEG. FAHR.
TURBINE WATER RATE EXCLUDING STEAM ADDED FOR BLEEDER = 17.88, VAC. 29 IN.
2 MACHINES 22,000 KW. EACH 44,000 KW. GENERATED
7 BOILERS ON LINE
PRESSURE AT BOILER 250 LB. GAGE
SUPERHEAT, 300 DEG. FAHR.
BOILER RATING, 176 PER CENT
BOILER, FURNACE AND ECONOMIZER EFFICIENCY, 80.4 PER CENT
COAL
41,032 LB. PER HR.
13,500 B.T.U. PER LB.
769,932,000 B.T.U.
BOILER, STOKER, STACK & RADIATION LOSS
HEAT RECLAIMED IN WATERBACKS
MISCELLANEOUS PLANT LOSSES
ECONOMIZER BLOW DOWN
BOILER BLOW DOWN
LINE RADIATION LOSSES
AUXILIARY STEAM 45,120 LB. = 58,701,120 B.T.U.
BOILER HOUSE H-P DRIPS
HEAT LOSS H-P DRIPS 3,630,120 B.T.U.
HEATER VENT LOSS
MAKE-UP
H-P TRAPS
TWO CONDENSATE PUMPS
TWO AIR PUMPS
ONE BOILER-FEED PUMP
TWO CIRCULATING PUMPS
BLEEDER
45,120 LB. PER HR.
44,106,080 B.T.U.
2 HEATERS
27,840,330 B.T.U.
CONDENSATE
471,870 LB. = 23,171,630 B.T.U.
WATERBACKS
RISE IN TEMP. = 10 DEG. FAHR.
81 DEG. + 10 DEG. = 91 DEG. FAHR. TEMP. TO HEATER.
BOILER FEED 552,300 LB. = 99,678,120 B.T.U. = 210 DEG. FAHR.
BEARING LOSS
GENERATION LOSSES
EXCITATION 200 KW. = 683,000 B.T.U.
STATION OUTPUT 42,800 KW. = 146,162,000 B.T.U.
STATION LIGHT & POWER 1,200 KW. = 4,098,000 B.T.U.
HEAT LOSS IN CIRCULATING WATER
I.D. FANS
F.D. FANS
7 STOKER MOTORS
MISCELLANEOUS POWER 1,451,798 B.T.U.

FIG. 1. HEAT BALANCE AT MOST ECONOMICAL LOAD
60,000-kw. generating station with 44,000-kw. load and 29-in. vacuum

The heat distribution diagram, Figs. 1 and 2, has been worked out, based on the present installation of two 30,000-kw. generating units. Fig. 1 illustrates the heat distribution for an hourly load at the most economical point of operation for the turbine, and with a vacuum of 29 in. Nearly all the values shown are based on the results of actual tests conducted on the apparatus since its installation.

The over-all efficiency of the boiler, stoker and economizer of 80.4 per cent, given on Fig. 1, is based on an actual test made during the month of June, 1921, when an efficiency of 81.7 per cent at a boiler rating of 176 per cent was obtained. A correction has been made on this diagram for the lower air temperatures that would prevail during the winter months, at which time a vacuum of 29 in. is obtainable.

Under "heater-vent losses" there has been included a loss of about 5 per cent of the exhaust steam used for feed-water heating. This loss would be difficult to measure with any accuracy, but we believe, from rough checks on heat absorbed in feed water, that the figure of 5 per cent should cover the losses at this point. The economizer and blowdown losses are correct within the limit of accuracy of the V-notch meter used to record these loses.

The heat distribution for the hourly condition, Fig. 1, does not, of course, make any allowances for banking or emptying of boilers for repairs. These are about the only losses that would occur over continued operation not included in this diagram.

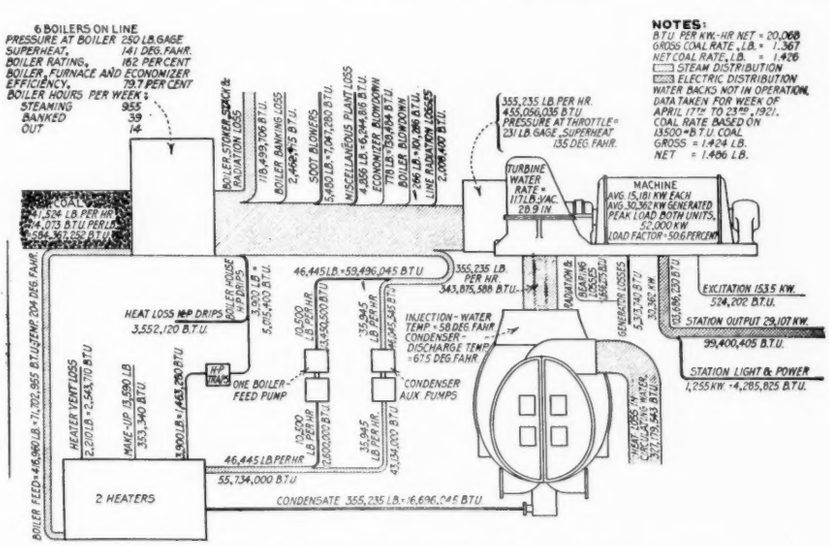

NOTES:
B.T.U. PER KW.-HR. NET = 20,068
GROSS COAL RATE, LB. = 1.367
NET COAL RATE, LB. = 1.426
STEAM DISTRIBUTION
ELECTRIC DISTRIBUTION
WATER BACKS NOT IN OPERATION.
DATA TAKEN FOR WEEK OF APRIL 17TH TO 23RD, 1921.
COAL RATE BASED ON 13500 = B.T.U. COAL
GROSS = 1.424 LB.
NET = 1.486 LB.
6 BOILERS ON LINE
PRESSURE AT BOILER 250 LB. GAGE
SUPERHEAT, 141 DEG. FAHR.
BOILER RATING, 162 PER CENT
BOILER, FURNACE AND ECONOMIZER EFFICIENCY, 79.7 PER CENT
BOILER HOURS PER WEEK:
STEAMING 955
BANKED 39
OUT 14
COAL
41,524 LB. PER HR.
14,075 B.T.U. PER LB.
584,362,550 B.T.U.
BOILER, STOKER, STACK & RADIATION LOSS
BOILER BANKING LOSS
SOOT BLOWERS
MISCELLANEOUS PLANT LOSS
ECONOMIZER BLOWDOWN
BOILER BLOWDOWN
LINE RADIATION LOSSES
355,235 LB. PER HR.
455,066,035 B.T.U.
PRESSURE AT THROTTLE = 231 LB. GAGE SUPERHEAT 135 DEG. FAHR.
TURBINE WATER RATE = 17.1 LB. VAC. 29.9 IN.
MACHINE
AVG. 15,181 KW. EACH
AVG. 30,362 KW GENERATED
PEAK LOAD BOTH UNITS, 32,000 KW.
LOAD FACTOR = 50.6 PERCENT
46,445 LB. = 59,496,045 B.T.U.
355,235 LB. PER HR. 343,875,588 B.T.U.
RADIATION & BEARING LOSSES
GENERATION LOSSES
EXCITATION 153.5 KW. 524,202 B.T.U.
STATION OUTPUT 29,107 KW. 99,400,405 B.T.U.
STATION LIGHT & POWER 1,255 KW. = 4,285,825 B.T.U.
BOILER HOUSE H-P DRIPS
HEAT LOSS H-P DRIPS 3,552,120 B.T.U.
INJECTION-WATER TEMP. = 58 DEG. FAHR.
CONDENSER-DISCHARGE TEMP. = 67.5 DEG. FAHR.
H-P TRAPS
ONE BOILER-FEED PUMP
CONDENSER AUX. PUMPS
HEATER VENT LOSS
MAKE-UP
BOILER FEED = 416,980 LB. = 71,302,955 B.T.U. FEED TEMP. 204 DEG. FAHR.
46,445 LB. PER HR.
55,734,000 B.T.U.
2 HEATERS
CONDENSATE 355,235 LB. = 16,696,045 B.T.U.

FIG. 2. HEAT BALANCE FOR ONE WEEK'S OPERATION
60,000-kw. generating station having average load of 30,362 kw. and vacuum of 28.9 in.

Fig. 2 illustrates the actual heat distribution over a period of one week, during April, 1921. It will be noted on this diagram that the load factor of the plant, based on its maximum capacity, was only slightly over 50 per cent, which means, in this case, that the average boiler efficiency is lower and the average turbine water rate higher than will be obtained under more favorable load

conditions. Several records of weekly coal rates that very nearly approach this result have been obtained with a lower load factor, and the plant operating over considerable periods of the day with light loads on the turbine.

A considerable difference will be noted between the heat value of the coal as used in this diagram and that used in Fig. 1. The coal was comparatively high in heat value during this week's operation, whereas the average over a longer period would be lower.

Throughout the week illustrated in this diagram, there were six boilers on the line, with the exception that over the week end, when the station load is usually low enough to be carried on one turbine, one boiler was taken out for repairs and cleaning. The banking hours represent the hours during which certain boilers were banked to take care of low-load conditions between midnight and 6 a.m. It was found more economical to bank boilers for this period than to operate the entire six at a lower rating.

Summarizing the heat-balance situation at this station, it is believed that, while there may be a slight loss in heat economy as compared with some other methods of obtaining heat balance, the very important item of reliability of service as obtained by this system and the ease with which it may be operated will offset the possible gains in heat economy secured by other systems.

Heat Balance of Connors Creek Plant

By C. Harold Berry and F. E. Moreton

At THE Connors Creek plant of the Detroit Edison Co. the main turbo-generators are six in number—three[1] of 20,000 kw., one of 30,000 kw. and two of 45,000 kw. capacity, giving a total installed capacity of 180,000 kw.[2] The boiler-feed pumps are steam-turbine-driven, with the exception of one which is motor-driven. One general service-water pump is steam-turbine driven. All other plant auxiliaries are motor driven, some by alternating-current motors, some by direct-current motors, the choice depending upon the nature of the driven unit. As it works out, those auxiliaries whose uninterrupted running is essential to plant operation are all driven by direct-current motors, while auxiliaries whose stoppage does not immediately affect the rest of the plant are driven by alternating-current motors. This division is not due to any belief in the superior reliability of direct-current motors, but is due to the fact that most, if not all, of the essential auxiliaries are of such character as to require or benefit from widely variable speed. Such are stokers, blowers, hotwell pumps[3], dry-vacuum pumps, circulating pumps, etc.

There are five house turbines on the system; three 1,000-kw. units and two 2,000-kw. units. The function of the house turbines is twofold—to furnish a stand-by source of power for station auxiliaries in the event of a system failure, and to furnish exhaust steam for boiler feed-water heating.

An auxiliary-exhaust heater receives the exhaust steam from the five house turbines, from six boiler feed-pump turbines and from one general-service-pump turbine, as well as the vapor formed in the boiler-feed makeup evaporators. This steam passes upward into five barometric-condenser heads, where it meets condensate from the main condensers. The resulting hot water is discharged into the hot boiler-feed tanks, whence it is pumped into the boilers. Inasmuch as these barometric condensers serve as condensers for the auxiliary system and as feed-water heaters for the main system, they are known as "heater condensers."

In the case of a plant like Connors Creek, the main units have a steam consumption of, say, 12 lb. per kw.-hr., wherefore power generated by them costs from 18,000 to 21,000 B.t.u. per kw.-hr. The house turbine, whose exhaust heat may be assumed to be fully utilized, produces power at a cost of 4,550 B.t.u. per kw.-hr. Clearly, the displacement of a portion of the power generated by the main units at high cost by power generated by the house turbine at much lower cost will result in a gain in station economy. From this it would appear that the maximum house-turbine output is to be striven for. But the matter is not so simple, for here is met the outstanding feature of the system—the auxiliary exhaust pressure may be adjusted to any value between the lowest attainable absolute pressure and atmospheric pressure. If operation is carried on at a very low pressure, the auxiliary exhaust steam, and therefore the boiler feed water, are at low temperature, with a resulting high cost of power from the main units. Further, with a small temperature rise of the boiler-feed water, very little exhaust steam can be condensed, wherefore the output of the house turbine is small. As the auxiliary-exhaust pressure rises, the boiler-feed temperature rises, lowering the cost of power from the main units, and at the same time the heat absorption of the boiler-feed water increases, condensing more auxiliary-exhaust steam and permitting the generation of more cheap power by the house turbine. As the auxiliary-exhaust pressure continues to rise, however, another influence enters: the steam consumption of the house turbine increases; that is, the power output of a given steam flow will be less. This reduces the proportion of cheap power generated, and eventually a point is reached at which an increase of auxiliary-exhaust pressure will decrease the station economy.

Maximum Station Economy

The problem then is to locate this point of maximum station economy. As is pointed out by the authors, a complete analysis of this problem requires a large fund of information, which unfortunately is not yet available for the Connors Creek plant. A study is, however, carried out in the paper for an assumed plant with characteristics consistent with the performance of Connors Creek. The results obtained serve to define the problem rather than to present a solution for the actual plant.

From the results the main facts, however, are clear. For a system of this type there is a best point, and it is just as wasteful to heat the feed water to a higher temperature as to a lower. The authors believe that for the Connors Creek plant the best economy is obtained with a boiler-feed temperature lying between 160 and 180 deg. F., and in this range they try to operate. A thermal balance sheet of the Connors Creek station, for April, 1921, is included in the paper, which shows a boiler efficiency of 75.1 per cent, a main-turbine efficiency of 25.4 per cent and a ratio of auxiliary to net delivered kilowatt-hours of 2.68 per cent.

[1] At the present writing one of these is in the manufacturer's plant in the course of rebuilding. A 10,000-kw. unit stands in its place.

[2] For the time being, 170,000 kw.

[3] At the time of writing, the older of these pumps still have induction motors, which are to be displaced by direct-current motors.

Heat Balance at Colfax Station*

By C. W. E. Clarke

COLFAX STATION of the Duquesne Light System, located at Cheswick, Pa., is designed for an ultimate gross capacity of 360,000 kw. and for a maximum output of 300,000 kw. The generating equipment as now planned will consist of six 60,000-kw. turbo-alternators, of which one is now in service and a second in process of installation. All condenser auxiliaries are motor-driven. Boiler-feed pumps and forced-draft fans are turbine-driven. All other station auxiliary apparatus is motor-driven. A 2,000-kw. house turbine is provided to supply auxiliary power. This turbine comprises part of the heat-balance system and exhausts into a barometric condenser, which acts as a feed-water heater.

There are two buses from which the auxiliaries may be supplied, one fed through a transformer bank from the main-station bus, and the other fed by the house turbine. These two buses are tied together through a motor-generator set, so arranged that energy can pass from the auxiliary bus to the house-turbine bus, but not in the opposite direction.

Due to the slip in the motor-generator set, the frequency produced by the generator is about 57 cycles when the main-bus frequency is 60 cycles. If the speed of the house turbine is varied so as to make its frequency slightly above or below that of the house-turbine bus, the amount of load carried by the house turbine will be correspondingly varied. This system of using a house turbine paralleled on the main bus is not new, but in existing installations of this kind considerable difficulty has been met with, due to differing characteristics of the small house turbine and the large units supplying the main bus. The motor-generator set was introduced into the system to avoid this difficulty. This piece of apparatus acts somewhat like a flexible coupling, taking up the momentary variations in frequency on both sides. This arrangement permits of any desired variation in the quantity of exhaust steam available for heating the feed-water since the greater part of the steam for feed heating comes from the house turbine. Its control can be practically accomplished by manipulation of the house-turbine governor control on the main switchboard alone. Manipulation of the barometric injection valve is occasionally necessary. A graphic recorder in the control room indicates the boiler-feed temperature so that the switchboard operator can maintain the boiler-feed temperature at any desired point.

The manipulation of this system is simple and positive. For days at a time the temperature in the boiler-feed tank will not vary more than one or two degrees from 210 deg. F. This variation is, of course, due to fluctuations in the total station auxiliary load, which are reflected in the house-turbine load. A series of experiments was recently conducted to determine how closely this system could be regulated and what the lag might be between the time that the load on the house turbine was changed and the time when the effect was noticed in the feed-water tank. It was found that any degree of regulation was possible. The house-turbine load could be varied in steps of 10 kw., it being impossible to read variations less than this. The feed-water temperature could be varied by amounts as low as 0.5 deg. F., which is as close as an ordinary thermometer can be read.

*See *Power*, April 5, May 3 and May 24, for detailed story of this station.

The table gives actual operating figures for a 24-hour day with a station load of 50,290 kw., a main-unit load of 50,615 kw., house-turbine load of 1,110 kw. and an auxiliary load of 1,435 kw. The average vacuum during this period was 28.94 in. There were two turbine-driven forced-draft fans and one boiler-feed pump in operation.

The figures given in the table are presented exactly as they were worked out, without change or adjustment. It is believed that the balances shown are as nearly true as it is possible to make them. The data given are not

HEAT-BALANCE TABLE FOR COLFAX STATION

	Pounds per Hour	Pressure, Lb. per Sq. In.	Sup'h't and Temp., Deg.	B.t.u. Above 32 Deg. F.
Steam produced	648,000	287	162	841,622,400
Steam to main unit	562,000	271	155	727,171,800
* Steam to house turbine	34,160	266	150	44,119,962
* Steam to feed pumps	13,460	266	150	17,375,514
* Steam to draft fans	24,860	266	150	32,091,774
* Steam to soot blowers	13,000	266	150	16,781,700
* Steam to drips returned, 532 d. temp.	500	...	...	250,000
Heat loss unaccounted for	.....	...	...	3,831,650
Total	648,000	.....	.....	841,622,400
Total heat in steam from boilers	.....	.....	.....	841,622,400
Total heat in feedwater	.....	.....	.....	106,552,640
Net heat added in boiler	.....	.....	.....	735,069,760
B.t.u. per kw-hr. (station load)	.....	.....	.....	14,600
Main unit input				
Steam to main unit	562,000	271	155	727,171,800
* Gland water	10,000	.....	96.29	642,920
* Condenser leakage	1,000	.....	52	20,000
* Expansion joint water	40,000	.....	96.29	2,571,680
Total	613,000	.....	.....	730,406,400
Main unit output				
Useful power (main unit load)	.....	.....	.....	172,850,225
* Steam leak h.-p. gland	3,000	271	155	3,881,700
* Vapor loss through air pump	1,000	.....	80	1,094,800
Condensate metered	605,000	.....	75	26,015,000
* Gland water leaks	1,000	.....	200	168,000
* Gland run-off	3,000	.....	200	504,000
Losses in main unit condenser, etc.	.....	.....	.....	525,892,675
Total	613,000	.....	.....	730,408,400
Available exhaust for feed heating				
* From house-turbine	34,180	14.24	0	39,296,746
* From house-turbine glands	1,000	14.24	0	1,149,700
* From feed pumps	13,460	17	101.6	16,164,114
* From feed-pump glands	500	17	101.6	600,450
* From draft fans	24,860	17	101.6	29,854,374
* From draft-fan glands	500	17	101.6	600,450
Total	74,500	.....	.....	87,665,834
Exhaust steam used				
In evaporator	11,700	17	101.6	14,050,530
In barometric	59,000	14.24	42.7	69,018,200
Returned as drips	1,000	.....	200	168,000
* Loss through relief valve	2,800	14.24	42.7	3,275,440
Losses unaccounted for	.....	.....	.....	1,153,664
Total	74,500	.....	.....	87,665,834
Evaporator				
Raw water	17,000	.....	49	289,000
Steam to evaporator	11,700	17	101.6	14,050,530
Condensate	605,000	.....	75	26,015,000
Total	633,700	.....	.....	40,354,530
From evaporator				
Condensate	605,000	.....	94	37,510,000
Distillate to head tank	28,700	.....	110	2,238,600
Total to head tank	633,700	.....	.....	39,748,600
Distillate to storage tank	0	.....	.....	0
Total from evaporator	633,700	.....	.....	39,748,600
To head tank				
Condensate	605,000	.....	94	37,510,000
From storage tank	8,500	.....	140	918,000
Distillate mixture	28,700	.....	110	2,238,600
* Main-unit gland run-off	3,000	.....	200	504,000
* Drips from boiler room	3,000	.....	200	504,000
Total to head tank	648,200	.....	96.29	41,674,600
From head tank				
To barometric heater	598,200	.....	96.29	38,460,000
* To main-unit glands	10,000	.....	96.29	642,920
* To expansion joints	40,000	.....	96.29	2,571,680
Total from head tank	648,200	.....	.....	41,674,600
To barometric heater				
Water from heat tank	598,200	.....	96.29	38,460,000
Steam	59,000	14.24	42.7	69,018,200
Total to heater	657,200	.....	195.54	107,478,200
To feed pumps				
* Live-steam drips returned	500	.....	200	84,000
* Low-pressure drips returned	1,000	.....	200	168,000
From barometric heater	657,200	.....	195.54	107,478,200
Total	658,700	.....	195.55	107,730,200
* Station-water losses	500	.....	195.55	81,775
Total to boilers	658,200	.....	195.55	107,648,425
* Boiler water lost	500	.....	.....	.....
* Boiler water returned	3,000	.....	.....	.....

* Estimated values.

considered representative of the best performance that can be expected from this station, but it is the intention to present in this paper only what has been actually accomplished.

Discussion on the Heat-Balance Papers

John A. Stevens called attention to the high pressures and temperatures being used in some of the later plants, notably the North Tees Station in England, with 475 lb. pressure and 720 deg. F. total temperature; the Paris station, with 350 lb. pressure and 750 deg.; also plants in this country, notably that of the Buffalo General Electric Co., the Joliet plant and the West Penn Station, in which high pressures and temperatures are used. In contrast to this the four stations forming the basis of the heat-balance papers have comparatively moderate pressures and temperatures. This, in Mr. Stevens' opinion, is a distinct backward step and he believes that new power stations should be designed for 350 lb. and 750 deg. temperature. As Mr. Stevens put it, American power-plant designing engineers should lead in the art and not follow.

In answering Mr. Stevens, C. W. E. Clarke expressed the opinion that American engineers were not attempting to construct engineering monuments, but power plants that possessed a high degree of reliability and that could be constructed to deliver a kilowatt-hour on the busbars with a minimum of cost commensurate with the capital and coal costs and other charges. J. H. Lawrence pointed out that the majority of the high-pressure and high-temperature stations in this country are now operating at reduced pressures and temperatures as it has been found that the impaired reliability and cost incident to apparatus being out of service will more than offset any increased theoretical economy.

N. E. Funk called attention to the apparent neglect of boiler-room losses in figuring the heat balance of the Colfax Station. He also took exception to Mr. Stevens' remarks concerning high boiler pressure and temperature and voiced the opinion that the problem narrowed down to a balance between investment cost and cost of fuel—in other words, that the aim should be to get the maximum dollar efficiency. Those responsible for the high-pressure European plants, Mr. Funk pointed out, have never been willing to tell what it costs them to run these plants. He was of the opinion that we had been going to the use of high pressures and temperatures too rapidly and that it would be a good idea to settle down for a year or two and gain more experience in present development.

In answering Mr. Funk's question on the Colfax Station, C. W. E. Clarke said that a net kilowatt-hour could be delivered to the busbar of this plant for 18,500 B.t.u.

Francis Hodgekinson was favorable to the electric drive in that it gets away from complications in the turbine basement, such as a mass of steam-piping, traps, etc.; he was also of the opinion that the greatest over-all economy is to be had by stage bleeding from the main turbine—preferably in connection with a house turbine.

George Orrok said that the selection of auxiliaries depends on the load conditions, and while admitting certain advantages for electric-driven auxiliaries, he was of the opinion that for certain load factors it would be possible to design a station with steam-turbine auxiliaries that would give just as efficient a heat balance as electric drives or various other combinations. J. H. Lawrence, in discussing this point, agreed with Mr. Orrok, but said that the power-plant designer cannot select the load factor as he had to design the plant to meet conditions as he found them.

H. R. Summerhayes pointed out that the fundamentals of power-plant economy were being more appreciated. For a long time there was an illusion as to the economy of steam-driven auxiliaries, it being considered that the efficiency of these units did not influence plant economy as long as the exhaust was used for feed-water heating. This, however, is now realized in general to be wrong. In most all cases the exhaust from small turbines is highly superheated. J. H. Lawrence called attention to one case where the exhaust was superheated to from 500 to 550 deg., and, due to the effects of the high-temperature steam on the turbine casing, it was necessary to line the machine up every three or four months. He expressed the opinion that unless the turbine had a water rate of about 30 lb. or less, the exhaust would be superheated.

In answer to the question in regard to two-stage feed-water heating C. H. Berry said that at Connors Creek Station they were at present using single-stage heating, but expected at some future date to use two-stage heating. In the high-temperature stage steam from the high-pressure seals would be used for heating.

A suggestion was made by a number of speakers as to the desirability of some standard form of making out a heat balance. In three of the papers presented heat-balance figures were given, but all three used a different method of showing the balance and, without considerable figuring, it would be difficult to reconcile one with the other.

A motion was offered by Charles Penrose that the papers on heat balance, along with the discussion on them, be printed, so as to make them available to members of the society and to all those who might be interested in power-plant design. The motion was carried to recommend to the council that this be done.

Making Work Fascinating as the First Step Toward Reduction of Waste

By Walter N. Polakov

INCREASED production has been sought by devising labor-saving machinery and by stimulating individual productivity of workers. The first method, while in itself productive of results, rapidly and inevitably develops the following two effects, which greatly reduce the advantages anticipated: (1) Automatic, high-speed machinery, sold at a high price, often increases overhead in excess of reduction in payroll, materially increasing the capital charges on manufacturing plants; (2) automatic, semi-automatic, high-speed and single-purpose machinery of modern industry makes the work of its attendants monotonous because it lacks the stimulating interest furnished by work requiring exercise of the mental faculties.

The general consequence of both these tendencies has been toward increased cost of production instead of the expected reduction of expenses. In times of industrial depression idle expensive equipment greatly increases the cost of ownership. The workers, on the other hand, failing to get stimulation and satisfaction from work as mere units of automatic machinery, demand shorter hours of this drudgery and higher com-

pensation with which they can buy the interest, stimulation and pleasure which they fail to find in the work itself.

The task before the engineer of today is to overcome the ill effects of the automatization and mechanization of industry. The world needs the highest possible production, and the workers demand creative self-expression in industry. The problem resolves into one of making work fascinating as a means of releasing the desire to work.

For some time past, studies of the industrial fatigue have attracted widespread attention, both in this country and abroad. It has been proved by various investigators that a great deal of waste in production is due to unnecessary fatigue as distinguished from that necessary for performing work under the most favorable conditions. An even more important finding, however, is that physical fatigue itself is largely traceable to mental and nervous fatigue, produced by the monotony of repetitive operation and other factors. Moreover, while mere physical fatigue gives to the man unmistakable warning, thus preventing physical breakdown, the nervous and mental fatigue accumulates unnoticed.

In this connection it is important to eliminate the monotony and make provision for something to stimulate the mind and the emotion, making work, at least in a measure, fascinating. When this is done, there will be a large reduction in such industrial waste as irregular attendance, large labor turnover, irritability of workers, inattentiveness, susceptibility to accident, poor workmanship, high percentage of spoilage, low individual output, etc. It would be a mistake, however, to think that monotonous repeating operations lack fascination to everyone. In fact, there are certain individuals who can best express themselves by performing a well-standardized operation.

In the author's experience in promoting and increasing industrial efficiency, he has found that the most fundamental, the most successful and the most enduring way to do it is by elevating man to his true dignity as an intelligent, creative agent. To be specific, the monotonous physical labor of a fireman is readily transfigured by special training into a fascinating game based on the exact sciences of physics and chemistry and requiring an array of mental capacities. Watching and interpreting a simple group of instruments provides men with interest, which is augmented as they intelligently control the processes and watch the results obtained.

Discussion

In the discussion, L. W. Wallace, Baltimore, Md., stated that while he considered that there was much of value in the paper, he could not agree that the cost of production had been increased by the use of specialized automatic machinery.

A. L. DeLeeuw, consulting engineer, New York City, asked how labor unrest could be laid to automatic machinery in view of the fact that only a small percentage of the workers operated such machinery. He stated that there was much unrest in fields such as the building industry, where automatic machinery was little used. The most important consideration, he said, was not the so-called "human relations" or "self expression," but rather, simple justice.

A number of persons, in addition to those mentioned, discussed the paper. Written discussions were submitted by Charles P. Steinmetz and Samuel Gompers. Mr. Gompers commended the paper and hoped it would receive wide publicity. Among other things, he said: "Higher wages mean increased opportunities for living, and shorter hours mean control over time, so that physical energy can be used with greatest effectiveness. Higher wages and shorter hours mean, for the wage earner, opportunity to mobilize his human ability for full expression. Labor realizes that upon management devolves the responsibility of developing the technique necessary to provide the methods whereby the creative ability we seek to conserve shall be released through opportunity to use brain, skill and human power in production."

In closing the discussion, Mr. Polakov said that the increase of prices in recent years was undeniable. He stated that one important cause of this was the fact that automatic machinery was necessarily idle much of the time. He then explained that his criticism of Taylor was not directed against the system in general, but against its attitude toward the worker.

Boiler Efficiency

By Victor J. Azbe

THE degree of waste in boiler plants is not generally realized, and there is a tendency to take good plants as representing the average. An over-all efficiency of from 45 to 50 per cent is probably not far from the average for small plants and is frequently found even in the larger plants.

Table I shows the principal results obtained in three tests of a B. & W. boiler of 2,690 sq.ft. heating surface, with a Jones stoker of an old type, burning Illinois screenings. Test A was made under ordinary operating conditions. Then improvements were made without altering the combustion space or stoker. After six months, test B was made, while test C represents the condition finally obtained by intelligent operation. The figures speak for themselves.

TABLE I. BOILER TESTS SHOWING IMPROVEMENT OF OPERATION

	A	B	C
Draft, drop through fire, in	3.45	3.76	4.05
Heating value of dry coal, B.t.u.	12,080	12,850	11,864
Per cent of rated capacity developed	102	140	185
Feedwater temperature, deg. F	180.6	187.0	176.8
Steam pressure, gage, lb	130	127	129
Temperature of flue gas, deg. F	612	533	532
Per cent CO_2	7.6	13.3	14.0
Over-all efficiency, per cent	56.0	68.5	78.1

With a suitable installation almost as high an efficiency can be obtained with low-grade as with high-grade fuel. As a rule low-grade fuel should be burned near the mines and higher-grade fuel transported. Both freight rates and costs should be compared on a B.t.u. basis.

Furnace volumes vary from 1 cu.ft. per lb. of coal burned per hour down to less than 0.1 cu.ft. in some cases. In the latter case some combustion necessarily takes place among the tubes. This is, of course, bad practice. Powdered fuel requires more combustion space. More than mere furnace volume is desirable. There are such things as effective and ineffective combustion space.

TABLE II. OPERATION CLASSIFIED ON BASIS OF FLUE-GAS TEMPERATURE

Per Cent Rating	Flue-Gas Temperature			
	Poor	Fair	Good	Very Good
100	560	520	480	440
150	660	610	550	500
200	760	700	630	540
250	...	780	700	600

With the modern large combustion spaces, the old

standards of 10 to 12 per cent of CO_2 should be raised to 16 per cent and excess air should be reduced to 25 per cent. Constancy of CO_2 is of some importance; a constant CO_2 of 10 per cent is better than a varying CO_2 averaging 10 per cent. It is not sufficient to know that the CO_2 is low at the uptake; it is important to find where the excess air gets in.

The ideal boiler installation of today should embody the following features:

1. A construction permitting counterflow, where flue gas will heat the feed water for the boiler, which will enter the boiler at as near the steam temperature as load fluctuation will permit.
2. A combustion chamber sufficiently large and effective throughout to prevent the entrance of any flame among the tubes.
3. Boiler spaces that will be effective throughout without dead spaces, and with the minimum draft drop for the given gas velocity. Gas velocity, the highest permissible, considering the cost of producing this velocity.
4. Fuel resistance overcome by forced draft.
5. The relative location of fire bed and heating surface such that the maximum possible amount of radiant heat will be transmitted to the boiler surface, consistent with complete combustion.
6. Tight boiler walls, properly insulated; probably an air-jacketed furnace, the air from which will be injected over the fire bed at high velocity to aid the mixing effect, or passed through the grate in the ordinary way.
7. A stoker permitting combustion with no more than 15 to 25 per cent excess air, no more than 1.2 per cent unburned carbon in the ashpit, no deposit of slag on the tubes. These conditions maintained at low and also at reasonably high rating.
8. Scale deposit in the boilers prevented by especially constructed, self-cleaning boiler; external chemical treatment of feed water; use of distilled makeup water; filtering of the water in the boiler by recirculation or by the combination of these methods.

Discussion

William S. Aldrich, referring to the diagram on which Table II was based, said that flue-gas temperature had to be considered in connection with CO_2. J. M. Spitzglass stressed the importance of the human element and suggested that the A.S.M.E. start a definite movement to make the boiler room attractive to high-grade men.

The importance of honorable design, operation and testing was brought out by J. C. Parker. D. S. Jacobus said that close attention must be given to the auxiliaries and to the general layout, as well as to the individual efficiency of the main units, if high plant efficiency is to be obtained.

Specific instances were given by David M. Myers of cases where the mere presence of records and interested persons, without any change in the equipment or scheme of operation, increased the plant efficiency by 15 per cent or more. Other speakers agreed that the human element was highly important.

Boiler and Furnace Economy

By D. S. Jacobus

IN DETERMINING whether it will pay to use economizers in a new plant the problem should not be approached by comparing the efficiency of a boiler with that of the same boiler with an economizer added to it. The proper way is to compare the results to be expected from boilers best suited for the service without the addition of economizers, with the results to be expected from the best combination of boilers and economizers. In the case of an old plant the question is a simpler one than for a new plant, as the added economy, due to the economizers, may be readily computed on the basis of known flue-gas temperatures, gas weights, etc.; but here again the load conditions must be taken into account, as well as the fact that there will be an increased cost of upkeep and added complications due to the necessity of installing an induced-draft apparatus. For peak-load service, with peaks of short duration, it does not ordinarily pay to install economizers on all of the boilers.

In designing a boiler for use without an economizer, additional efficiency may be secured by adding to the height of the boiler. Increasing the height from 14 tubes high to 20 tubes high, for example, will result in a considerable increase in efficiency with but little increase in the draft loss. In many cases the higher boilers may be operated with natural draft at the desired capacity.

It is becoming more general practice to use an individual economizer for each boiler, and not to install connections for bypassing the flue gases around the economizer. A bypass connection often results in leakage and loss of economy.

A question frequently arises as to what is the most economical capacity or rating at which to run a boiler. This cannot be answered in a general way, as it depends on the load conditions as well as the class and cost of the fuel, the presence or absence of economizers and the service to which the boilers are put. Where there are short peak-load periods, the greatest commercial economy is usually secured by operating the boilers at as high a capacity as can be secured during these periods.

High efficiency is closely associated with high combustion temperatures, but a definite limitation is placed on these by the ability of firebrick and other refractories now obtainable to stand temperatures that could otherwise easily be obtained in boiler furnaces. As the art stands today, most of the thickness of the brickwork must be cooled to a temperature below, say, 2,200 deg. F. in order that the bricks or tiles may carry the load imposed on them. As furnace temperatures considerably higher than this may exist, it is apparent that the necessity of maintaining the brickwork below the temperature of the furnace is a vital one. First-class clay brick has a fusion point slightly above 3,100 deg. F., and begins to yield long before it fuses.

To consume combustible gases within the furnace chamber, there should be a proper length of flame travel before the gases strike the tubes, and a sufficient furnace volume. In addition to this there must be a mingling action within the furnace to cause any unconsumed combustible gases to reach the excess air. This means that the furnace should be so constructed as to prevent the formation of "lanes" of gases carrying excess air. Where two lines of stokers are used with the dumping plate at the middle line of the furnace, the furnace should be made high enough to allow the lean gases which come at the middle of the furnace to form eddying currents with the hot gases, and thereby search out the combustible matter.

The effect of the absorption of radiant heat on the boiler tubes should be considered in designing a furnace. With the stronger fuels it is necessary to absorb

a considerable amount of radiant heat in order to prevent collapse of the brickwork, or at least an undue amount of deterioration. Few realize how great a proportion of the heat may be absorbed by a boiler as radiant heat. In underfeed-stoker practice, with the baffle arrangement ordinarily offered with B. & W. boilers, the absorption of radiant heat when operating at normal rated capacity, is over 60 per cent of the total heat absorption. The chief advantage of exposing tubes to radiant heat is not any gain in efficiency, but a slight reduction in the temperature of the combustion space with a correspondingly increased life of the brickwork.

Irrespective of how well a boiler plant may be designed, it will not give the best results unless it is properly operated. High-grade men are required in the boiler room. The old idea that a man should graduate from the boiler room to the engine room is a mistake. On account of bad conditions existing in many boiler rooms, the fireman is often blamed as the chief cause of fuel waste. The difficulty is seldom with the fireman, but is in his having nothing to guide him except what might be called his intuition. It is certainly a mistake not to provide proper instruments. This is well appreciated in the larger and better-operated power plants. High-class instruments and apparatus for guiding the fireman or controlling the combustion will not of themselves, however, insure good results, unless they are in the hands of a capable man who believes in them.

Furnace and boiler design must be co-ordinated in order to secure the best results. It is impossible to separate the boiler efficiency from the efficiency of the stoker and furnace in such a way that the value obtained for the efficiency of the boiler will depend solely on the construction of the boiler and not be influenced by the construction of the stoker and furnace.

Discussion

The paper of Doctor Jacobus met with a most favorable reception and was followed by a discussion that brought out points of great practical value.

Trouble with air preheaters was predicted by A. D. Bailey, if they were used with coals of high sulphur content. This, he said, would come from corrosion of the preheater and also from clinkering due to high furnace temperatures. In his opinion it was first necessary to educate the management if boiler-room conditions were to be improved.

E. L. Hopping gave the following as the two main points kept in mind in designing the boiler settings at the Philadelphia Electric Company: (1) Enough combustion space for the highest ratings to be carried; (2) ease of changing over to other fuels or methods of combustion. He said that proper design would eliminate the cinder nuisance.

E. B. Ricketts outlined some of the devices used in high-temperature metallurgical furnaces as suggestive of what might be done with boiler furnaces. He discussed the two following methods of lowering the temperature of furnace walls: (1) Water-filled tubes embedded in the brickwork at the proper depth; (2) hollow walls with circulating air. Both methods permit the conservation of the heat taken from the walls. Firebrick, he said, should be true so that mortar joints could be made very thin.

A. A. Cary did not agree that the separate efficiencies of boiler and furnace were meaningless. While granting that the boiler efficiency was somewhat dependent on that of the furnace, he emphasized the importance of separating the combined efficiency into its elements in order to locate and remedy the losses. In this connection Mr. Cary stated that gas samples should be taken at the termination of the furnace as well as at the uptake.

The opinion was expressed by D. M. Myers that conservation by individual initiative was a failure. He recommended public action to protect the common interests of the people and made several specific suggestions, including the establishment of educational courses and the licensing of firemen on the basis of a knowledge of combustion.

Fuel Saving in Relation to Capital Necessary

By Joseph Harrington

SOMETHING definite and reliable in the way of information for the enlightenment and guidance of the prospective investor in equipment seems to be needed, and the object of this paper is to provide evidence to support the rather general understanding that it pays to economize.

An investigation made in an attempt to gather information from consulting engineers, chief engineers of power plants, and owners, showed that only about 5 per cent had any records or data on which to base actual figures. This is a serious situation. However, it has been possible to find a few cases where figures were available on which to base this article.

It often is the case that an investment in the proper coal-burning equipment will yield a yearly return as high as 100 per cent, due to reduction of coal burned or the ability to use a cheaper grade of coal. This statement is supported by specific evidence in many cases. For instance, the power plant of the Waterloo, Cedar Falls and Northern R.R. was overhauled in the fall of 1913. The author followed this installation through for two years thereafter, the results being published in the Aug. 22, 1916, issue of *Power*. In this case four boilers, each having 5,000 sq.ft. of heating surface, were installed to replace older water-tube boilers which had been fired with the same make of stoker. With the same stoker, the same fuel and similar boilers the saving may be very definitely attributed to the greater efficiency secured by the more modern setting. Not only was the furnace better proportioned and made more ample, but instruments and other efficiency equipment, such as gas-analysis recorders, draft gages, recording thermometers, feed-water heaters and coal-weighing equipment, were installed. A simple system was developed for watching the indication of these instruments and drawing therefrom the logical deductions. In this particular instance the new equipment actually paid for itself in a little over a year.

During the summer of 1919 the Armour Institute of Technology made a change in their mechanical stokers from the old-style chain grate to the new traveling grate, boiler conditions remaining exactly the same. The modern stoker had a smaller grate area and was designed to be more efficient at the lower ratings which occurred during the major portion of the year. Only for about two months during the year was the boiler worked up to anywhere near its capacity. Records of evaporation had been kept from June, 1914, to June,

1919, on the old equipment. Similar records were kept for the ensuing year on the new equipment. These showed a saving in one year of 274 tons of coal, which at $5.67 per ton on the boiler-room floor amounted to $1,553, or a return of 33 per cent on the investment.

Discussion

R. L. Beers stated that small hand-fired plants offered the greatest opportunity for improvement. He said that stokers were ordinarily a paying investment even in small plants, because their main advantage was the saving of coal rather than labor. The latter item was, of course, not to be neglected. He told of one small plant where $1,500, spent to purchase and install a stoker, saved $900 a year in coal alone. Several examples of large savings were given by other speakers.

W. N. Polakov stressed the importance of the human element. The great difference between test and operating results was largely due, in his opinion, to the fact that in tests interest and brains were coupled with hands, and monotony was lacking. He concluded that a great increase in economy would result if these elements could be introduced into daily operation. E. N. Trump told of a very large boiler plant, operating at good efficiency, that was replaced by a stoker-fired plant. Increased economy paid for this installation in five years.

Emergency Fleet Corporation Water-Tube Boilers for Wood Ships

By F. W. Dean

IN A PAPER presented to the society in 1919 by the author and Henry Kreisinger, on coal-fuel tests of Emergency Fleet Corporation water-tube boilers for wood ships,[1] it was stated that oil tests were being made. The principal results of these tests are given in the present original paper, but this abstract deals mainly with one type of burner.

In consequence of the introduction of oil for fuel on many of the steamships belonging to the United States Shipping Board, it became desirable to ascertain the relative merits of several of the mechanical atomizing oil burners for boilers. The tests were made under the direction of the writer, assisted by Henry Kreisinger, then fuel engineer of the Bureau of Mines. Fig. 1 shows the type of boiler tested as it appeared before the oil burners were applied. In changing over to oil burning, a few alterations were made in the firebrick lining, and a layer of insulating brick was added.

TESTS WITH NAVY STANDARD REGISTER BURNER

Duration of trial, hours	7.17	8.00	7.00	5.00
Number of burners used	4	4	4	4
Dimensions and Proportions:				
Furnace volume, cu.ft.	408	408	408	408
Heating surface, sq.ft.	2,518	2,518	2,518	2,518
Average Pressures:				
Steam pressure gage, lb.	200.2	203.1	193.6	201.0
Draft between damper and boiler, in.	0.38	0.95	1.90	2.51
Feed-water temp., deg. F.	116.0	68.6	73.7	91.7
Temp. flue gas, deg. F.	414	465	538	583
Fuel Data:				
Oil consumed per hour, lb.	527.0	807.8	1,341.0	1,584.6
Temp. of oil at burners, deg. F.	266	276.5	260	281
Pressure of oil at burners, lb.	146.2	249.3	228	236.4
Heat value per lb. of oil, B.t.u.	18,376	18,352	18,376	18,376
Specific gravity at 60 deg. F.	0.962	0.960	0.962	0.962
Viscosity, deg. Engler, at 65.5 deg. C.	20.39	.....	.....	20.39
Flash temp., deg. F.	167	158	167	167
Fire point, deg. F.	270	266	270	270
Quality of Steam:				
Moisture in steam, per cent	1.11	0.91	0.87	0.93
Evaporation per lb. Oil:				
Actual evaporation, lb.	12.50	12.12	12.22	12.27
Equivalent evaporation, lb.	14.38	14.53	14.57	14.40
Efficiency:				
Over-all efficiency, per cent	75.9	76.8	77.0	76.1
Capacity:				
Per cent of land rating obtained	88	136	227	265
Per cent of marine rating obtained	51	78	130	152

Mexican oil was used because it is the only oil that is usually available for steamship fuel. Some of the properties of the oil used are given in the table of test results.

Six kinds of burners were used, all of mechanical atomizing types, but only No. 1 is designated by name. No. 1 was the United States Navy Bureau (of Steam

[1] Abstract of this paper was published in the March 2, 1920, issue of *Power*, starting on page 348.

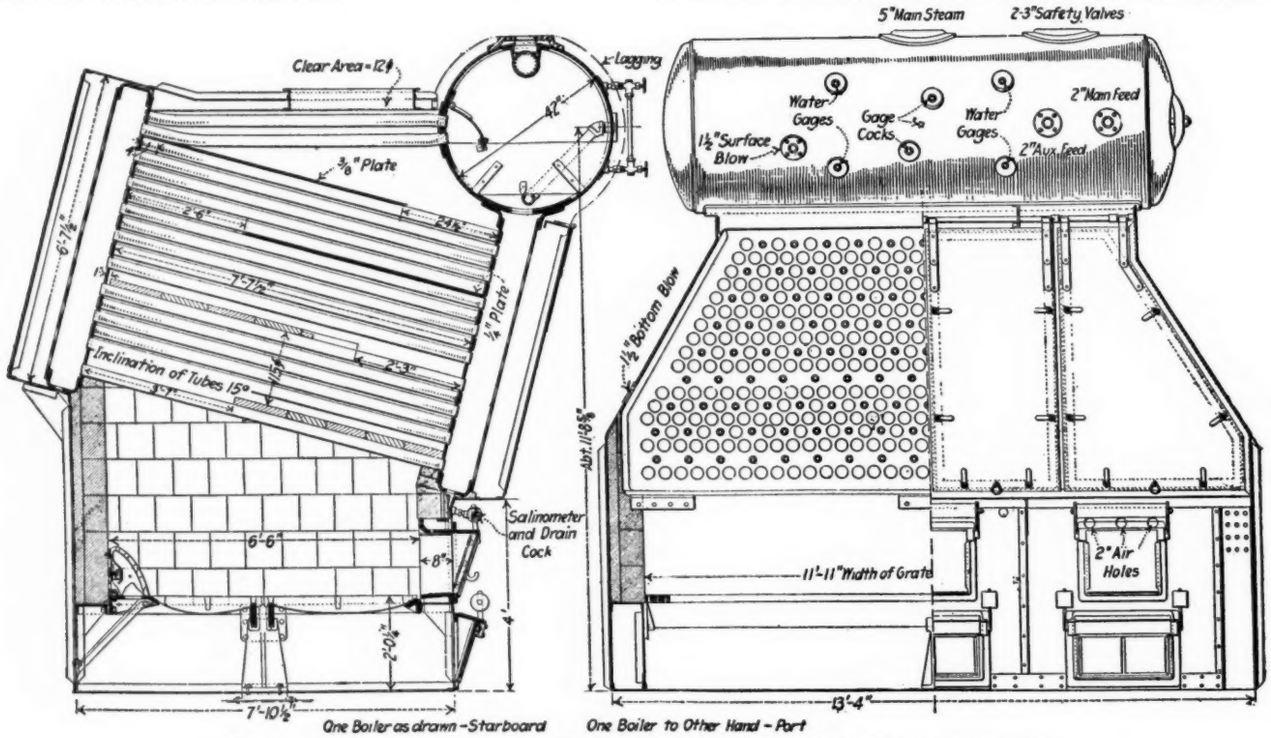


FIG. 1. TYPE OF BOILER TESTED (BEFORE ADAPTATION TO OIL BURNING)

Engineering) standard register burner. In each case four burners were applied to the burner and usually they were all in use.

The Navy standard register burner, No. 1, is shown in Fig. 2 and consists of a circular cast-iron register with inclined blades around the outside, through which air passes and acquires a rotary motion. The oil is discharged from the tip with a rotary motion which causes it to spread into the form of a thin hollow cone.

Various adjustments can be made as follows: (A) The whole or any part of the register can pass air, or it

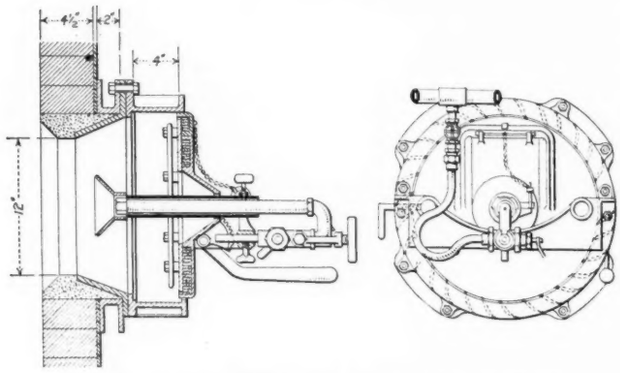


FIG. 2. NAVY STANDARD REGISTER BURNER

can be completely closed by means of a movable circular plate fitting inside of it. (B) the burner pipe, with tip and spray cone, can be moved in or out as a unit; (C) the spray cone can be moved in or out with respect to the tip.

The other burners have tips that rotate the oil, as this is indispensable in thinning the oil film, but burner No. 4 rotates the air but little and No. 6 not at all. This demonstrates that the rotation of the air is not necessary, a conclusion that might otherwise have been reached.

After preliminary tests to determine how to operate the burners properly, several tests were run with each type of burner. The accompanying table shows some of the more important data from four of the six tests made with No. 1 burner.

Complete data for six tests on burner No. 1, and also for three other burners, are given in the original paper. The other burners are there designated as No. 3, No. 4 and No. 6.

Discussion

Speaking of stationary oil-fired boilers, C. B. Goode said that there was sometimes trouble due to softening of the brickwork at high temperatures. J. J. Nelis called attention to the fact that marine boilers are not ordinarily run at as high ratings as are common on land. The melting that occurred in these tests was only at ratings above marine practice.

John A. Stevens referred to the oil-burning equipment on the "Aquitania" as an example of a very fine installation. The CO_2, he said, averaged around 12½ per cent, which was good for the Scotch marine type of boiler. The use of oil for fuel on this ship saved 450 firemen and trimmers.

The results of other marine tests were given by N. E. Lewis, who also made the statement that a well-designed mechanical oil burner requires less attention than any other fuel-burning apparatus.

Steam Condensing Plants—New Type of Surface Condenser Described

By Paul A. Bancel

This paper consists of two main parts, the first of these being an analysis of the elements of condenser design, selection and operation. The following are a few of the points brought out in this first section.

The choice of a condenser involves many considerations including those of boiler-room operation. Sometimes the selection of surface condensers means condenser trouble, while the selection of jet condensers means boiler troubles due to bad feed water. Aside from first cost, which depends largely on the vacuum desired, the chief elements are tube renewals and power for auxiliaries. The life of the tubes depends not only on their quality, but also on the design of the condenser. High velocities and low temperatures throughout will greatly prolong the life of the tubes, and these in turn depend on condenser design as well as on the quantity and temperature of cooling water.

After further discussion of the effect of various factors on the operating charges, Mr. Bancel described a new type of surface condenser made by the Ingersoll-Rand Co. The main points are given here.

Condenser Design

The design of a surface condenser to conform with the requirements that have been outlined, lies in the proper application of certain well-known principles. The first of these is to keep all the tubes uniformly hot on the steam side so that the minimum number will be needed because none is wasted. To accomplish this, the steam must be free to flow to all the tubes and over all the tubes, with slight loss of pressure and temperature, the condenser being arranged in stages, much as is a turbine, with large flow areas at the exhaust entrance and great distances between rows.

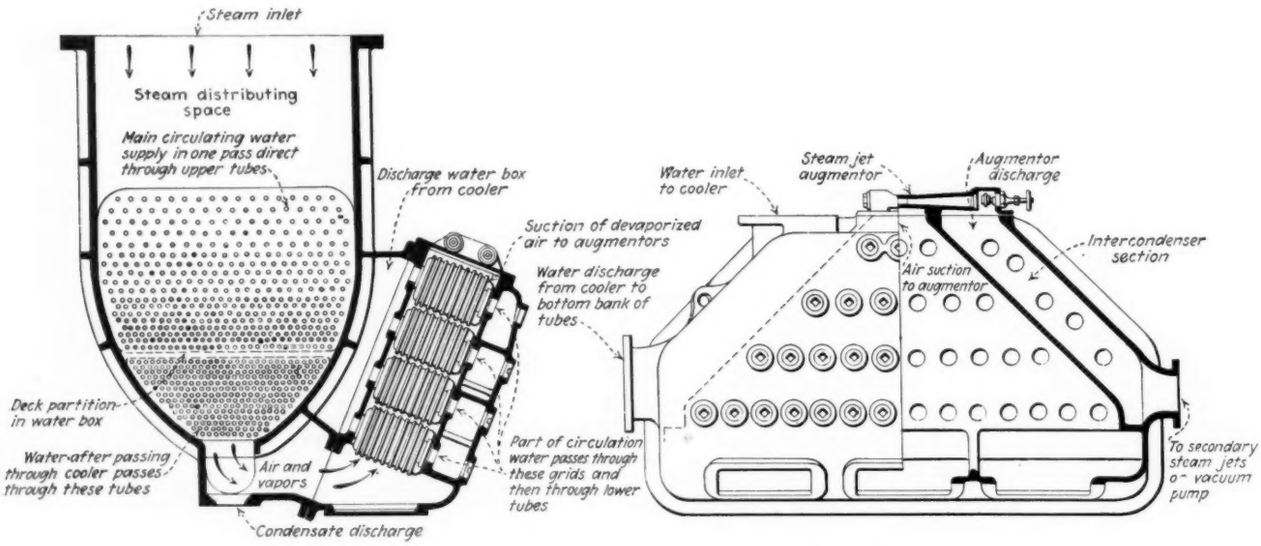
Of equal importance in keeping all tubes hot is the proper staging to maintain velocities that will sweep the air ahead in the current of steam and the arrangement of tubes in staggered rows so that none is shielded or pocketed. Air left on a tube after condensation would otherwise stratify in a thick layer in a few seconds. With high steam velocities, all of the tube is hot because the air is continually carried away in the current of steam. Experiment has shown that this current is most active in producing heat transfer in front of the tube—the side about 90 per cent active and the back about 75 per cent. This indicates the importance of staggered tube arrangement so that the front of each tube is presented to the steam flow.

The steam velocities must be sustained throughout the depth of the condenser, which requires not only proper tube spacing, but a shell of decreasing width; that is, a wedge- or heart-shaped shell terminating in a narrow, slot-shaped outlet (as shown in figure). In this respect also the condenser is analogous to the turbine, which has both changing blade height and changing wheel diameters.

If the foregoing conditions are maintained, the mixture of steam and air is kept homogeneous and the temperature does not fall until a surprisingly large percentage of steam has been abstracted and the process

almost completed. Starting with approximately 92-deg. temperature, there is no perceptible fall of temperature due to increasing air richness until over 99 per cent of the heat has been abstracted and over 99 per cent of the steam condensed. Thereafter the temperature falls at an increasing rate, depending upon the proportion of air to steam in the original mixture.

This process is no longer rapid condensation, but a matter of devaporization, to reduce vapor temperature and pressure and increase partial air pressure, so that the air may be removed by a vacuum pump. It is best carried out in a chamber external to the main condenser, forming a devaporizer or cooler. The figure illustrates such an arrangement in which the flow of hot vapors and air taken from the bottom of the main condensing chamber are turned upward into a cooler from which the concentrated air is finally removed at the top. It will be noticed that this cooler is also of wedge shape, decreasing in area as the outlet is approached. The air is withdrawn by steam-jet augmentors which discharge into an intercondenser section forming part of the cooler. The air at reduced vacuum is then withdrawn and compressed to atmosphere by secondary steam jets or a small reciprocating pump. In one case a single small pump is used as a secondary for two condensers, steam-jet secondaries being installed as stand-bys.


Steam inlet
Steam distributing space
Main circulating water supply in one pass direct through upper tubes
Discharge water box from cooler
Suction of devaporized air to augmentors
Water discharge from cooler to bottom bank of tubes
Deck partition in water box
Water after passing through cooler passes through these tubes
Air and vapors
Part of circulation water passes through these grids and then through lower tubes
Condensate discharge
Water inlet to cooler
Steam jet augmentor
Augmentor discharge
Intercondenser section
Air suction to augmentor
To secondary steam jets or vacuum pump

CROSS-SECTION OF INGERSOLL-RAND CONDENSER

The work of devaporization is done by cast-iron grids with fins, assembled in the cooler shell, where they are held in place and connected to the water spaces of the cooler by large cast-iron bushings. Cold circulating water flows through the cores of the grids with only slight rise in temperature and then passes through the bottom group of tubes in the condenser.

Discussion

A. G. Christie said that the reasoning seemed to be logical, but that more information on certain points, such as the rate of heat-transfer secured, would be desirable. He also said that many engineers would welcome further discussion on the subject of tube corrosion.

A number of criticisms were made by D. K. Dean, who questioned the superiority of the heart-shaped condenser and the validity of some of Mr. Bancel's arguments. He called attention to the necessity for a separate de-humidifier, or air cooler, which added to the cost and the space taken, and expressed the belief that a two-pass condenser was superior to one with a single pass.

Similar criticisms were made by John F. Grace, who said there were many other methods of securing velocity control aside from the use of the heart-shaped type of condenser. He also condemned the use of small tubes, claiming that they would cause trouble where dirty water was used. He preferred the internal type of air cooler to the external type.

P. E. Reynolds praised the paper as a clear presentation of new applications of old ideas. The slow progress in condenser design was due, he said, to the great expense of conducting the right kind of tests. The design presented seemed logical, so far as he could determine, but he expressed a desire for some information as to the actual test results obtained with this condenser. Without these, he said, no conclusions could be reached.

The Vertical Triple-Expansion Pumping Engine

By L. A. Quayle and E. H. Brown

Cleveland, Ohio's, installations during the past 65 years make an interesting study both of the improvement that has been made in the economy of pumping engines and the increase in energy available to the engine which has resulted from successive increases in steam pressure and temperature. These installations also cover the period of the introduction of stoker firing.

The duty of 53,000,000 ft.-lb. per 100 lb. of coal obtained by the very-slow-speed but well-made Cornish engines with which the Water Works began operation in 1856, using 22 lb. gage steam pressure, was better than was obtained from the Knowles engines purchased 31 years later and operated at a boiler pressure over three times as great.

The first decided increases in Cleveland's pumping-engine duties came with the installation, in 1893, of the

Worthington high-duty engine, a type in which the steam was worked expansively in a multiple-cylinder compound engine without a crankshaft and flywheel, and with the installation of the Allis, Holly and Kilby vertical, triple-expansion crank-and-flywheel engines in 1898 to 1901.

The steam pressure, which for the first installation in 1856 was 22 lb. gage, was raised to 60 lb. in 1872; to 75 lb. in 1883; to 100 lb. in 1893; to 150 lb. in 1898, and to 210 lb. when Division Station was rebuilt and put into service in 1917.

The original paper outlines in considerable detail the many changes that have taken place in the Cleveland pumping equipment from 1856, when the first installation was put in operation, until the present time. The record is one of remarkable improvements in the over-all efficiency of the pumping stations, due in large part to higher steam pressures and improved steam-generating equipment.

TEST OF ALLIS-CHALMERS PUMPING ENGINE (NO. 4)

Diameter of steam cylinders, in.	36—68—108
Stroke of steam pistons and water plungers, in.	66
Number of water plungers (single-acting)	3
Diameter of each plunger, in.	31.63
Type of condenser	Surface
Diameter of flywheels, ft.	20
Number of flywheels	2
Weight of one flywheel, tons	37.5
Total weight of engine, tons	950
Average Pressure and Temperatures:	
Steam pressure at throttle, gage, lb.	207.1
Vacuum in condenser (30 in. barometer)	28.26
Superheat at throttle, deg. F.	136.0
Water pressure in force main, lb.	169.9
Total head pumped against, ft.	377.2
Speed:	
Revolutions per minute	20.93
Power:	
Work done per hour, million ft.-lb.	2,659
Water horsepower	1,343
Combined hydraulic and mechanical efficiency, per cent.	94.79
Capacity:	
Rate of pumpage, million gal. per 24 hr.	20.29
Percentage of rated capacity developed	101.5
Economy and Efficiency:	
Thermal efficiency of entire unit, per cent	24.27
Ratio of thermal efficiency of entire unit to that of the ideal Rankine Cycle	77.22
Steam consumed per water hp.-hr., lb.	9.38
Steam consumed per i.hp.-hr., lb.	8.89
Duty:	
Work per million heat units, million ft.-lb.	188.7
Work per 1,000 lb. steam, million ft.-lb.	211.0

In 1917 Cleveland's new Division Avenue Pumping Station was put into service. As far as the authors have been able to determine, the average duty of this station with a performance equivalent to 127,000,000 ft.-lb. of work per 100 lb. of coal fired, is not exceeded by any other coal-fired pumping plant in which the normal low cost of coal does not warrant investment in economizers. This low coal consumption is due to the use of efficient boiler and stoker equipment, operated under constant engineering supervision, and the use of highly efficient triple-expansion engines working under 210 lb. steam pressure and 120 to 150 deg. superheat.

Our investigation also leads us to believe that this station contains at least one and possibly four engines whose duty record and thermal efficiency have never been equaled by any other steam-driven pumping engine. The best economy obtained on any one of these four engines is 211,000,000 ft.-lb of work per 1,000 lb. of steam used and 24.3 per cent thermal efficiency.

The remarkable thermal efficiency of 24.3 per cent was obtained in a test, made on Oct. 15, 1918, on the Allis-Chalmers vertical, triple-expansion engine, No. 4. The results obtained are believed to be very reliable on account of the highly accurate testing equipment and methods employed. The table shows some of the more important data and results of this test.

Discussion

In opening the discussion, George A. Orrok referred to the paper as the culmination of thirty years of effort along these lines by members of the A.S.M.E., and agreed that the efficiencies reported exceeded any others of which he knew. He expressed regret that the engine performance had not been shown on the temperature-entropy diagram instead of the Mollier diagram.

George H. Gibson, while admitting the high efficiency of the reciprocating type of pumping engine, predicted that it would be supplanted by the turbine-driven centrifugal pump with double-helical reduction gearing.

A. G. Christie expressed the opinion that the turbine-driven centrifugal pump could not approach the economy of the reciprocating equipment, but that steam economy was only one element in determining the commercial desirability of equipment. In his opinion, however, the reciprocating pump was more reliable.

George A. Gibson, in further discussion, told of two large centrifugal pumps located in Minneapolis, that in two years had shown no falling off from the original efficiency of 86 per cent. He believed that reduced efficiency was ordinarily due to leakage through the wearing rings and that this could be largely eliminated by proper design. He said that turbine-driven centrifugal pumps were now available with duties up to 160,000 ft.-lb. per 1,000 lb. of steam. After telling of a Pittsburgh installation, where reduction gearing had been in continuous satisfactory operation since 1910, Mr. Gibson called attention to the fact that the reciprocating equipment was much more expensive, took more space and required heavier foundations and larger buildings.

Compounding a Remedy for Difficulties with Diesel

By Elmer A. Sperry

In a report by a group of engineers in 1900, it was stated that if the combustion engine could be successfully compounded, a most important gain would be made in its weight and size. The fact that compounding presents other advantages has been known to engineers for a number of years, but the difficulties have been looked upon as insurmountable. The fact that Diesel himself in the 90's undertook the construction of a compound, the total failure of which received wide publicity, reports of these failures finally getting into textbooks, seemed to give substantial corroboration to this point of view. One eminent German authority, Güldner, set the final seal of "impossibility" upon it with characteristic Teutonic finality.

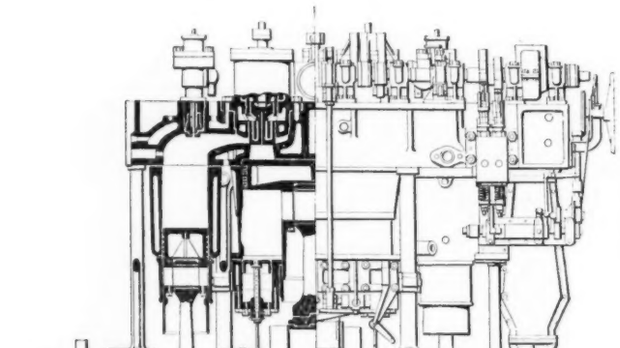
His statement has probably done more to retard combustion-engine advance, especially in this important phase, than anything published in the last two decades. A close study of Diesel's embodiment, in view of present knowledge, reveals a total lack of most of the features that we now recognize as essential to success. There have been one or two isolated workers in England and Germany who have not been so ready to believe this statement, feeling that the next great step in combustion engines, as in the case of steam, is bound

to be compounding, but practical difficulties still intervened and no advance was made or even serious work done until within the last two years.

The Author's Early Work in Compounding

In America a group headed by the author has been engaged on this problem for upward of thirty years. Starting in 1890, his first compound was running before the World's Fair. The patent records give evidence of this early work under date of Dec. 10, 1892. A number of engines have steadily followed, each involving improvements resulting from previous experience, until the essential problems have been conquered.

The outcome has been that the various prophecies of thoughtful engineers in the past have been more than fulfilled and there is every evidence that the heavy-



SPERRY COMPOUND DIESEL ENGINE

duty compound combustion engine is everything that was hoped for. It is light compared with the normal Diesel, being in special cases less than one-tenth, and in some instances less than one-twentieth, in weight for the same output. Its mechanical efficiency is extremely high, a distinct gain in over-all efficiency from fuel to shaft has been made, as well as a very definite gain in simplicity, direct performance and smoothness of the crankshaft diagram. This has been achieved while adhering to the best practice, namely, four-stroke-cycle operation.

Compounds Lighter and Cheaper—Much Larger Units Possible

The lightness and simplicity of the compound solves the capital-charge factor automatically. Engines and machinery in the final analysis usually cost a given amount per pound. It is found that there is no structural demand or refinement in the compound that has not already been met in the Diesel—the same range of pressures and temperatures are handled throughout by the effective two-stage method, which is now well established. Engines of this type weighing only a fraction of the weight of the present Diesel will inevitably be found to be much less in first cost and upkeep.

The large volume of power gases in the combustion chamber of the compound at once solves a number of important problems, makes the light engine easy of accomplishment and overcomes a number of other difficulties at the same time. No longer is the chilled perimeter per unit volume of gas the controlling factor, as it is in the Diesel. The chilled walls are retired into the background as the large volume asserts itself, as compared with the small crevice indicating the total volume available in the normal Diesel, where the chilled areas exposed are very large and the volume very small. At a glance it will be seen that all this is reversed completely in the large dome-shaped clearance space, where the volume has increased much more rapidly than the perimeter. This is again vastly increased in the low-pressure cylinder, where an extremely large volume exists with still smaller ratio of chilled perimeter. Taking all the chambers into consideration, it is found that, while retaining all the chilled walls that are necessary for proper handling of the lubrication, still a gain is made on the order of 60 per cent in the extent of these chilled walls in the compound as compared with the simple engine.

Solid Fuel Injection

With the large clearance volume we no longer have difficulty with solid injection, nor do we have any difficulty in using a wide range of heavy fuels. It has been known for years that as soon as the oil spray encounters chilled or even red-hot walls, the efficiency drops. Here the oil fog may penetrate the deep masses of hot compressed air with instantaneous effect in every direction from the spray nozzle without encountering chilled walls, and instantaneous and very complete combustion results. In the compound engine the clearance volume is so large that the entire high-pressure piston displacement causes it to lose only a fraction of its pressure, thus bringing to the second stage, or low pressure, both ample volume and pressure so that this piston (representing 6, 8 or even 10 times the area of the high-pressure) is driven to the end of its stroke with pressures still above the atmosphere.

Much Greater Expansion, Higher Efficiencies

In this way the engine yields an expansion ratio based on gage pressures, which instead of being 3 or 4 to 1, as in the case of the automobile engine, or about 12 to 1 in the Diesel, can be made as high as 120 to 1. Yielding a higher return and greater efficiency from the fuel because of the lower temperature of the exhaust, similarly the high-vacuum steam turbine secures higher efficiency by its much greater ratio of expansion as compared with the reciprocating engine. The great volume in the combustion space, furthermore, allows this space, without distortion, to extend easily out over the top of the low-pressure piston, making a most direct connection therewith through a short transfer port. And finally, this large clearance space allows its shape and contour to be grouped almost solely with reference to the most complete dissemination of the fuel and highest combustion efficiency.

Field of Usefulness of the New Prime Mover

To engineers versed in the problems of selecting and designing prime movers, the advantages of the compound combustion engine are readily apparent. Its light weight for a given power with resulting low first cost and capital charge, the low costs for foundations, the high speeds with consequent low costs for connected generators, the small space required and the simplicity and economy of operation are important reasons for suggesting new fields for this prime mover, which has been proved of practical value in a long series of tests under working conditions.

Steam-Electric Central Stations Retained for the Superpower System

Coal Consumption and Cost—Production Cost per Kilowatt-Hour—Investment Cost per Kilowatt of Effective Capacity—Operation of Retained Plants as Part of the Superpower System

By ARTHUR R. WELLWOOD
Formerly Assistant Engineer-Secretary, Superpower Survey

THE rapid increase in electric-light and power loads during the last decade brought about by the greater demand of domestic, industrial and railway consumers, has caused noteworthy advances to be made in the design, construction and operation of steam-electric generating stations throughout the United States. Credit should be given those engineers who have been responsible for this progress, especially for the advance made in the development and refinement of the better and more efficient mechanical and electrical equipment that has been installed in a number of the new plants constructed during this period.

Factors Entering Into the Choice of Plants

In selecting the steam-electric central stations that exist in the Superpower Zone, for the Superpower System, a careful study was made of each individual plant. The matter of plant location with its attendant vital requisites was considered seriously, and the following main factors were determined upon before proceeding with the detailed analysis:

1. Availability of water supply to insure a sufficient amount of condensing water.
2. Close proximity to railroads or waterways to see if coal-delivery and storage facilities permitted of the economical handling of fuel.
3. Local consideration, such as how densely populated in the immediate surroundings.
4. Proximity to center of gravity of system as modified by conditions found in items 1 to 3 inclusive.

The majority of plants chosen satisfied these requirements, although, of course, there were cases where local conditions would not allow of all the factors being satisfied. If the latter plants were selected, they were chosen on the merits of some other points considered, which are discussed later on in this article.

It was found in studying the design of most of the new steam-electric central stations retained for the Superpower System, and in the additions and alterations to most of the old plants, that the companies had well provided against possible interruption and shut-down. In some cases this task was extremely difficult, especially where all the plants in a city or district were interconnected. In such cases provision was made to eliminate the possibility of tying up the whole system on account of short-circuits, blowouts or other accidents occurring in one particular plant. This was accomplished through reactance and the thorough insulation of all feeders, connections, leads and buses and also through their isolation so as to eliminate the possibility of communication from one line to the other.

The additions and alterations to old plants consisted mainly in the installation of additional units of large capacity and in the replacement of old machines by new units. This replacement of small-sized units by larger ones is a result of the lower production costs obtainable through the operation of the latter, provided load conditions justify the change.

Full cognizance was taken of the efficiencies and economies prevailing in a number of the larger plants

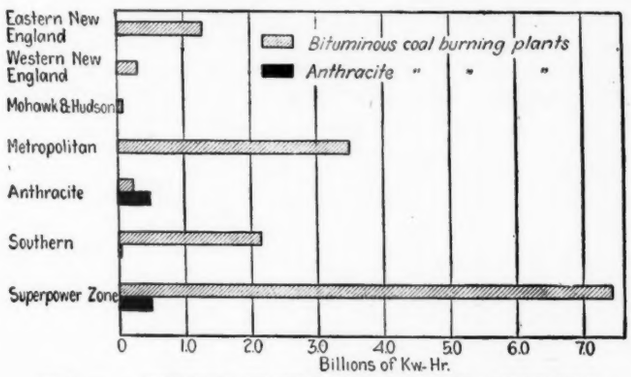


FIG. 1. OUTPUT OF EXISTING STEAM-ELECTRIC CENTRAL STATIONS IN 1919, RETAINED FOR THE SUPERPOWER SYSTEM — BY GEOGRAPHIC DIVISIONS AND FOR SUPERPOWER ZONE

in the zone, and a number of them will play a very important part in the operation of the Superpower System. The smaller, older and less efficient plants in the zone have been discarded, and these represent but 20 per cent of the total existing plants.

The existing steam-electric central stations retained for the Superpower System therefore represent approximately 80 per cent of all the steam-electric central stations in the Superpower Zone, and as previously stated, they were chosen as a result of a detailed analysis and study based upon their 1919 performance. Whereas the most important factor entering into the choice of plants was individual fuel performance, still other factors in addition to the ones mentioned were considered in the matter of choice. These factors were:

1. The particular locations of the plants in respect to their ultimate use for voltage regulation purposes.
2. Their adaptability to the future expansion of the Superpower System.

Plant Capacity Retained

The retained steam-electric central stations include both bituminous and anthracite-coal burning plants, the division between the two being approximately 95 per cent for the bituminous and 5 per cent for the anthracite plants.

The total effective power-plant capacity[1] retained in

[1] Effective capacity as used in this article is the rated capacity of a plant as limited by boilers, prime movers or generators.

existing central stations is 2,676,630 kw. Of this amount 19 per cent is in the Eastern New England division, 6.2 per cent in the Western New England division, 0.5 per cent in the Hudson division, 1.9 per cent in the Mohawk division, 42.2 per cent in the Metropolitan division, 6 per cent in the Anthracite division and 24.2 per cent in the Southern. In the Anthracite and Southern divisions there are both bituminous and anthracite coal burning stations retained. Of the total effective capacity retained in the Anthracite division, 70 per cent is in anthracite plants and 30 per cent in bituminous plants, while in the Southern division approximately 3 per cent is in anthracite plants and 97 per cent in bituminous plants.

Actual 1919 Output

The actual output in 1919 for the retained plants is shown in Fig. 1 by geographic divisions and for the zone. The chart shows the division of output between the bituminous coal burning plants and the anthracite coal burning plants in the Anthracite and Southern divisions, also for the Superpower Zone.

The maximum consumption is clearly seen to be in the

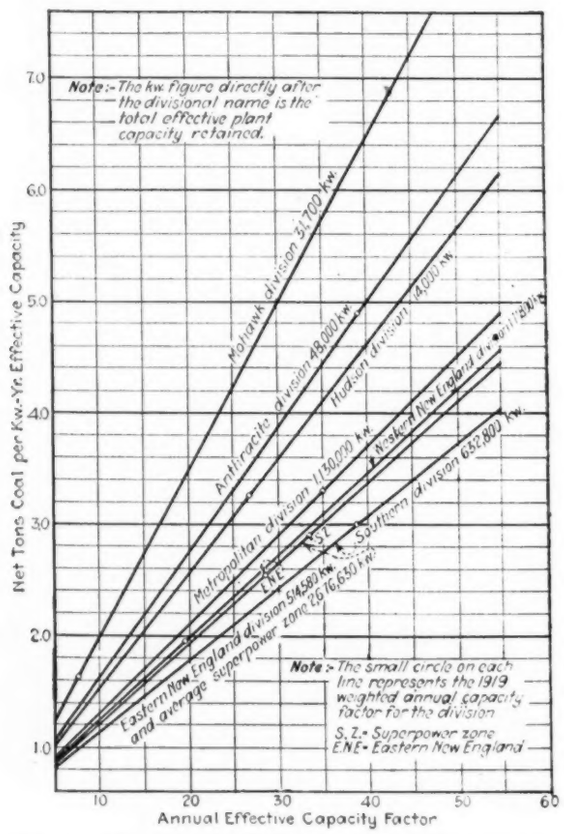

Note:- The kw figure directly after the divisional name is the total effective plant capacity retained.
Mohawk division 31,700 kw.
Anthracite division 48,000 kw.
Hudson division 14,000 kw.
Western New England division 73,000 kw.
Metropolitan division 1130,000 kw.
Southern division 652,800 kw.
ENE
WNE
S.Z.
Eastern New England division 514,580 kw.
and average superpower zone 2676,630 kw.
Note:- The small circle on each line represents the 1919 weighted annual capacity factor for the division
S.Z.- Superpower zone
E.N.E.- Eastern New England
Net Tons Coal per Kw.-Yr. Effective Capacity
Annual Effective Capacity Factor

FIG. 2. WEIGHTED FUEL PERFORMANCE, AVERAGE OF STEAM-ELECTRIC STATIONS RETAINED FOR SUPERPOWER SYSTEM USING BITUMINOUS COAL—BY GEOGRAPHIC DIVISIONS AND FOR SUPERPOWER ZONE

Metropolitan division, while the Southern division is next, with the Eastern New England division third.

This brings out the concentration of load in these divisions and shows the tremendous possibilities of decentralization brought out in the article "The Performance and Cost of the Superpower System," published in *Power*, Nov. 8, 1921.

The coal consumption of the retained plants in 1919 was as follows:

	Bituminous Coal, Net Tons	Anthracite, Net Tons
Eastern New England	1,318,500	.....
Western New England	330,800	.....
Mohawk and Hudson	97,500	.....
Metropolitan	3,734,000	.....
Anthracite	234,900	979,500
Southern	1,887,900	44,300
Superpower Zone	7,603,600	1,023,800

The net tons of coal per kilowatt-year of effective capacity are shown for the bituminous coal burning plants and the anthracite coal burning plants in

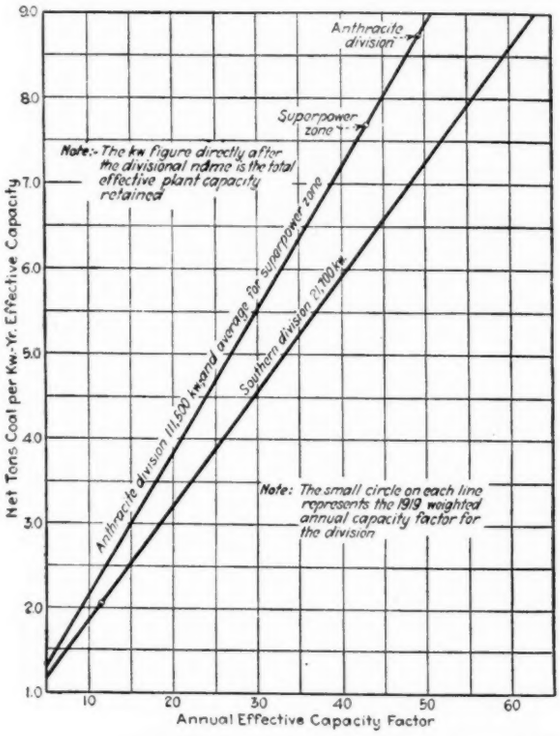

Anthracite division
Superpower zone
Note:- The kw figure directly after the divisional name is the total effective plant capacity retained
Anthracite division 111,500 kw and average for superpower zone
Southern division 214,700 kw
Note: The small circle on each line represents the 1919 weighted annual capacity factor for the division
Net Tons Coal per Kw.-Yr. Effective Capacity
Annual Effective Capacity Factor

FIG. 3. WEIGHTED FUEL PERFORMANCE, AVERAGES OF EXISTING STEAM-ELECTRIC CENTRAL STATIONS RETAINED FOR SUPERPOWER SYSTEM USING ANTHRACITE — BY GEOGRAPHIC DIVISIONS AND FOR SUPERPOWER ZONE

Figs. 2 and 3 respectively. These curves represent the weighted average of all the plants retained in each division and clearly show the advantage of operating plants at high capacity factors[2]. The weighted annual capacity factors at which the plants operated during 1919 is shown in the small circle on Figs. 2 and 3, and the total effective plant capacity retained in each division is the figure given after each divisional name.

The actual weighted average cost of both bituminous and anthracite coal per net ton delivered to the bunkers of all the existing steam-electric central stations in the Superpower Zone was $5.35. The weighted average unit costs by divisions ranged from $3.05 per net ton delivered for the Anthracite division to $7.10 for the Eastern New England division.

Production Costs

Fig. 4 shows the total annual production costs per kilowatt-hour of the retained steam-electric central stations according to geographic divisions and for the

[2]Capacity factor as used in this article is the average load on a plant expressed as a percentage of the effective capacity of the plant.

total Superpower Zone. These are the actual weighted average costs for the year 1919 as submitted by the utility companies and represent the cost of power at their busbars. It is interesting to note the variation in the cost of fuel and the way in which this cost is reflected in the total annual-operating expense. With the exception of the Mohawk and Hudson division, the New England divisions have the highest unit cost

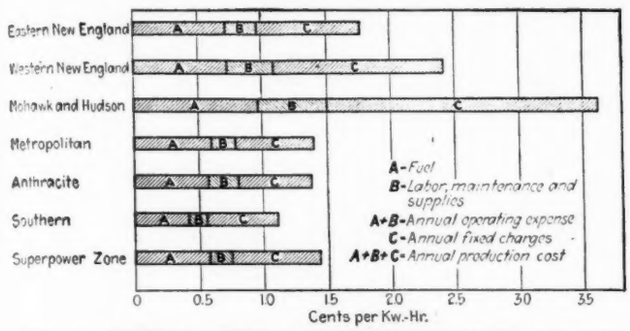


FIG. 4. ACTUAL ANNUAL PRODUCTION COSTS OF THE RETAINED STEAM-ELECTRIC CENTRAL STATIONS IN THE SUPERPOWER ZONE FOR 1919

of fuel. This higher cost is accounted for by the fact that the cities in the New England divisions have to pay a higher freight rate than the cities in the other divisions. The high production cost for the Mohawk and Hudson divisions is caused largely by the fact that a great many of the steam-electric central stations are used only for peak-load purposes and are consequently operated at very low capacity factors. Hydro-electric plants are used to carry the load in these divisions and are operated at high capacity factors. The second item making up the total annual operating expense is that of labor, maintenance and supplies. This item of necessity varies according to local conditions in each particular plant, and undoubtedly there is reflected in some of these costs, work that was postponed on account of war conditions. In studying the curves, it must be remembered that these plants were all operating under different capacity factors and that the advantage of operating at high capacity factors is reflected especially in the cases of the Metropolitan, Anthracite and Southern divisions.

Investment in Retained Stations

The total investment in the retained steam-electric central stations for the entire Superpower Zone based on reproduction values as of midyear 1919, was $329,219,000. The unit investment costs per kilowatt of effective capacity for each division and for the zone are as follows: Eastern New England, $129; Western New England, $143; Mohawk, $158.50; Hudson, $155; Metropolitan, $114.20; Anthracite, $142; Southern, $121.80; total Superpower Zone, $123. These unit costs are weighted averages and cannot therefore be applied as the reproduction value of any one specific plant. The figures used in determining them were submitted by the utility companies and represent their best estimates.

Fixed charges have been taken as 16 per cent of the total investment cost and include such items as the cost of money, bond discounts and profit, taxes and insurance. The total annual fixed charge for retained plants in the Superpower Zone is $52,620,000. The annual fixed charges per kilowatt of effective capacity ranges from $18.30 in the Metropolitan division to $25.40 in the Mohawk division. All other divisions lie between these two figures, while the average for the Superpower Zone is $19.70.

Operation of Retained Plants

In the operation of the Superpower System for the year 1930, the retained steam-electric central stations will operate at a weighted annual capacity factor of 17.1 per cent. The capacity represented by these plants provides 33 per cent of the total capacity required to satisfy the 1930 conditions and furnishes 12.6 per cent of the total output in kilowatt-hours. From these facts it will be readily observed that whereas the retained plants account for one-third of the installed capacity, they contribute only about 12 per cent of the energy requirements. This condition is the result of operating the retained plants at low annual capacity factors, and the new base-load plants at high annual-capacity factors. Greater efficiency, better economy and lower production costs are the results of such operation. The older and less efficient plants will be used to swing peaks and for stand-by emergency purposes, while the new and larger plants will carry the load.

The fuel rate for the retained steam-electric central stations for 1930 is 2.64 lb. per kw.-hr. For the new steam plants as operated in 1930 it is 1.43 lb., while the average rate for both old and new plants is 1.62 lb. per kw.-hr. This average rate compared to the actual fuel rate of 2.73 lb. per kw.-hr. for the electric-central stations in the Superpower Zone operating during

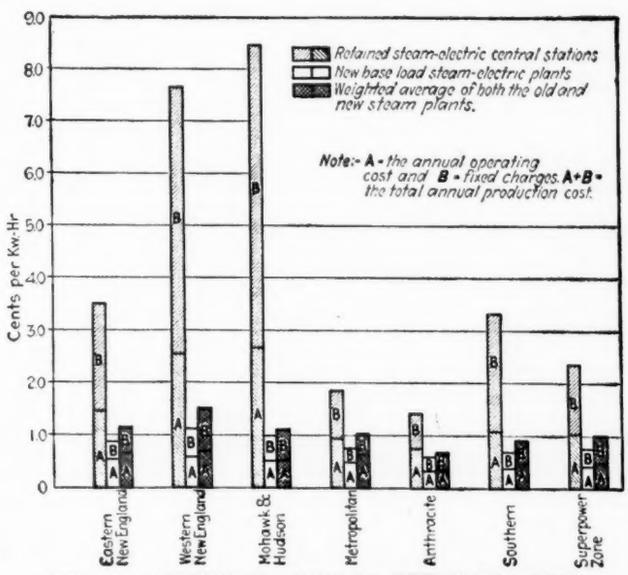


FIG. 5. ESTIMATED ANNUAL STEAM-ELECTRIC PRODUCTION COSTS OF THE SUPERPOWER SYSTEM FOR 1930

1919, accounts for the enormous saving in fuel that can be accomplished through the agency of a Superpower System. In the year 1930 the annual saving through superpower operation is 19,149,000 net tons of coal from the electric utilities for steam-electric produced power. The weighted average cost of coal delivered to the Superpower System for 1930 is $5.25; the value of fuel saving is therefore $100,500,000 for the electric public utilities.

The total annual production cost of the retained

steam-electric plants is compared to the annual production cost of the new steam-electric plants and also to the average production cost of both the old and the new steam-electric plants in Fig. 5. This chart is for steam-electric produced power only and the costs should not be interpreted as the annual production costs of the Superpower System. The system costs are in reality less than shown in Fig. 5, due to the lower cost of hydro-electric produced power. This statement does not hold true for the Anthracite division, however, where, on account of the low cost of fuel, steam-electric power can be produced for 6.7 mills per kw.-hr. as against 1.55c. per kw.-hr. for the hydro-electric produced power. This high cost of hydro-electric power in the Anthracite division is an exception and is due to the small capacity of the hydro plants. In general hydro-electric power can be produced at a lower cost than steam-electric. The total production cost of hydro-electric produced power for the entire Superpower System for the year 1930 is 5.8 mills. By reference to Fig. 5 it will be seen that the total annual production cost of steam-electric produced power for the entire Superpower System is 1.02c. per kw.-hr. The total annual production cost of both steam-electric and hydro-electric produced power for old and new plants is therefore 9.3 mills per kilowatt hour.

A glance at Fig. 5 will show that the production costs for the retained steam-electric central stations are a great deal higher than they are for the new base-load plants. This is but a natural consequence of operating the old plants at low capacity factors. It must also be borne in mind that there is a considerable difference in the efficiencies obtained by these old plants. This fact accounts for the wide difference observed in the operating costs among the various geographic divisions.

Abandoned Plants

During the year 1919 there were 400 steam-electric central stations in the Superpower Zone from which to choose the plants which would be retained for operation in the Superpower System. As stated previously, approximately 80 per cent, or 320 of these were incorporated in the Superpower System, leaving the remainder, or 80 plants, representing 703,370 kw. of installed effective capacity to be discarded. These plants did not meet the requirements as set forth in the first part of this article, and in addition they are at a disadvantage in being smaller in size, less efficient and less economical.

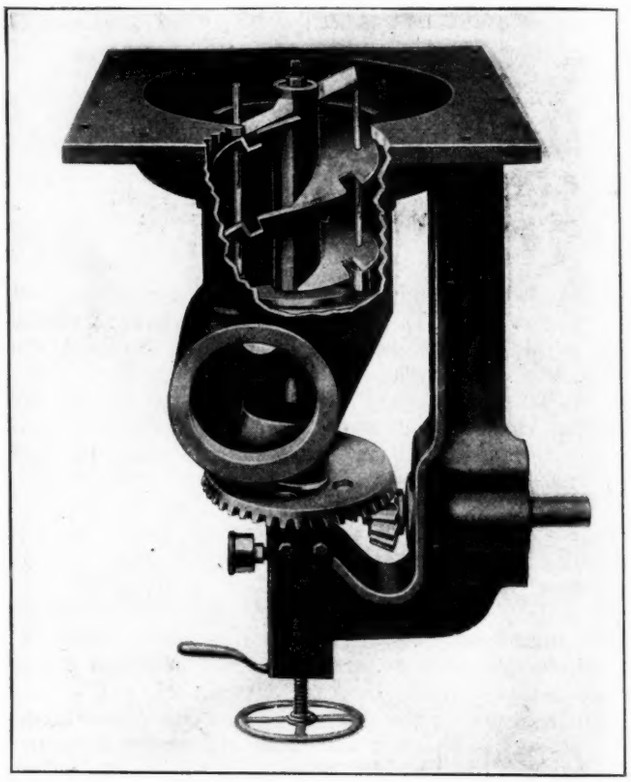
Based on reproduction values as the midyear 1919, the total investment in abandoned plants is $181,931,000. In order to amortize these plants, it will be necessary to provide a sinking fund of $17,800,000 per annum. On a 7 per cent annuity basis the complete amortization of the abandoned steam electric-central stations will be accomplished in about eight years.

Fuller S-H Pulverized-Coal Feeder

The Fuller S-H Feeder is a simple pulverized-coal feeding apparatus that is designed to give a regular and uniform rate of flow and is adjustable to meet the variable fuel requirements of the furnace through a wide operating range. The feeder embodies a hopper reservoir that incloses an inverted cone valve mounted on a vertical shaft. Two spiral propeller blades and agitator bars are attached to and rotate with the shaft, the whole being driven by a gear and pinion.

The shaft assembly has a limited vertical motion controlled by a handwheel that raises or lowers the valve with respect to its seat, thus governing the rate of flow of material to the burner.

Agitator bars loosen the coal in the bin overhead, thus obviating any tendency to arch. They also push away from the screw any foreign material that may get into the bin, depositing this material in a side recess. The double-flight spiral revolves in a direction tending to raise the coal, thereby keeping it in an agitated flocculent state, in which condition it naturally flows by gravity through notches and through the valve opening into a primary air chamber from which it is carried by a stream of air to the furnace. In a nearly closed position of the valve the lower edges of the screw scrape away material that tends to collect around the valve.



PULVERIZED-COAL FEEDER

The vertical pins revolve with the screw and always rest on the valve seat. The arrangement is such that the screw flights may move vertically without lifting the pins. Their function is to sweep the valve seat and prevent the accumulation of coal which might interfere with the lowering of the valve. Wear on the valve and seat in a closed position is prevented by a collar or stop which does not permit the valve to be screwed down tight.

This feeder operates at a low constant speed, the feed being regulated by raising or lowering the valve. It will not choke or clog in case the air flow is shut off. It will not flood, as the upward action of the screw carries away the bulk of the fuel from the air stream and only the coal fed through the notches can be delivered to the burner.

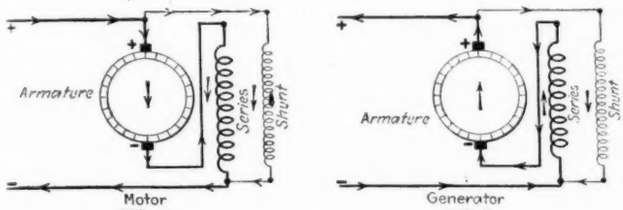
The rated capacity ranges from 0 to 11.2 lb. of coal per minute with the feeder running at 15 r.p.m.; from 0 to 22.3 lb. at 30 r.p.m.; 0 to 34.5 lb. at 45 r.p.m.; and 0 to 44.6 lb. at 60 revolutions per minute.

Experiences of an Elevator Maintenance Man

He Tells How the Trouble Was Located and Remedied on an Elevator That Was Running Too Fast

BY CHARLES A. ARMSTRONG

IN NEARLY all cases where direct current is available, compound-wound motors are used in elevator service. The purpose of the series winding is to increase the torque during the starting period. Since in elevator service starting and stopping are frequent, it is essential that the motor be capable of getting the



FIGS. 1 AND 2. SCHEMATIC DIAGRAMS OF A MOTOR AND A GENERATOR

machine up to full speed in the minimum time consistent with smooth operation, if the maximum of service is to be obtained. To obtain rapid acceleration and constant speed with a direct-current motor, a compound type must be used.

When the elevator is lowering a heavy load, the motor runs slightly faster than when lifting a load. This small increase in speed is sufficient to increase the counter-electromotive force in the armature above the line volts and the motor is converted into a generator. Under such conditions the motor delivers current into the line, and this current flowing through the armature conductors causes the motor to act as a brake and prevents the load from being lowered at a high speed.

When a compound motor is converted into a generator, the current remains in the same direction in the shunt winding, but is reversed through the series winding.

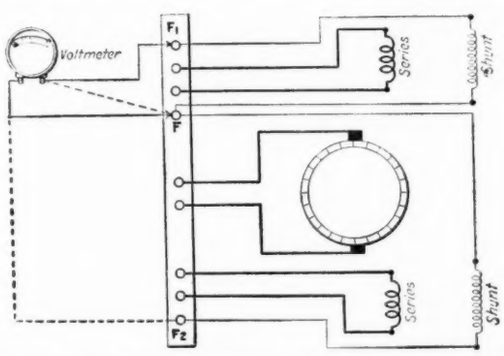


FIG. 3. METHOD OF TESTING FOR LOOSE CONNECTION IN SHUNT-FIELD COILS

Consequently, if the current flows in the same direction through the series- and shunt-field windings when the machine is operating as a motor, it will be in opposition in the two windings when the machine is running as a generator, as indicated in Figs. 1 and 2. For this reason provisions are made in elevator controllers for cutting out the series winding after the motor has started; that is, the motor starts as a compound type and is then converted into a shunt machine. On the down motion with a heavy load the elevator will race if the series-field winding is not cut out of circuit, on account of the series field opposing the shunt.

If an elevator machine lowering a load has a tendency to race, it will generally be found that owing to some misadjustment the controller is not cutting out the series-field winding. Where the machine races on the up motion, the trouble may be due to various causes. A rather baffling case of such trouble was experienced recently by the writer. The elevator machine had been complained of as racing in the up motion at irregular intervals, but it apparently would not do it twice under the same conditions. This trouble might occur once in one day and not again for a day or so. Then it might happen two or three times in a short period, but always before anyone had an opportunity to see the machine operating erratically, the trouble would have cleared.

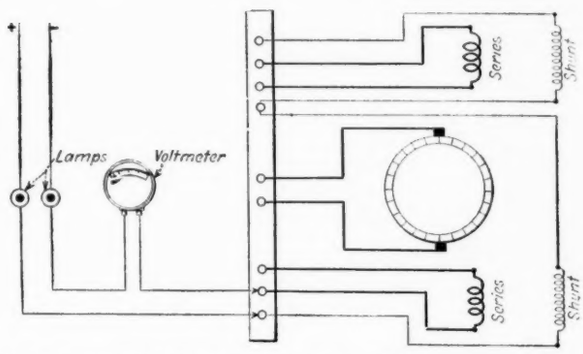


FIG. 4. TESTING FOR SHORT-CIRCUITS BETWEEN SERIES- AND SHUNT-FIELD COILS

Therefore it became a case of trying to conceive of what might be the trouble and test for this.

A loose connection sometimes occurs in the shunt-field circuit that may partly open this circuit under certain conditions and cause the motor to race. As this was about the simplest thing to think of, it was tested for first. The motor had two poles, and the two shunt coils were connected in series at a binding post on the terminal board, making in all three shunt-field terminals, on the terminal block. To test for a loose connection in the shunt-field winding, a voltmeter was connected from F to F_1 as in the Fig. 3. The field winding being connected across 240 volts, the voltmeter, when connected to the terminals of one coil, indicated one-half of 240, or 120 volts. When the machine was started, the voltmeter needle gave a throw forward of about 50 volts, showing that for some reason the opposition to the flow of the current through this coil had increased. This would indicate that there was a poor connection in this coil and during the starting period the connection loosened up and caused the resistance of the circuit to increase. To verify this, the voltmeter was connected across the other coil from F to F_2, as indicated by the dotted lines. When the machine was started again, the needle dropped below the 120-volt

mark. Apparently, the trouble must be in the coil giving the high reading.

When making decisions on the results of tests obtained from electrical machinery, especially if putting the decision into effect will involve considerable expense, it is well to make sure that the conclusions are correct. One of the best ways to do this is to try every conceivable way to prove the conclusions wrong. If the first findings will stand the acid test, then you are fairly safe in acting on them. One thing that did not look right with the voltmeter test was that the deflections were regular each time the motor started, whereas if a loose connection was causing the trouble the throw of the needle would have been more erratic; that is, at one starting practically no deflection would be obtained, while at other times it would be considerable. So it was decided to look further for the seat of the trouble.

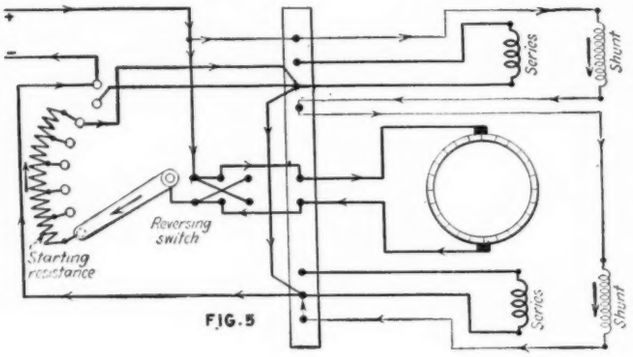


FIG. 5

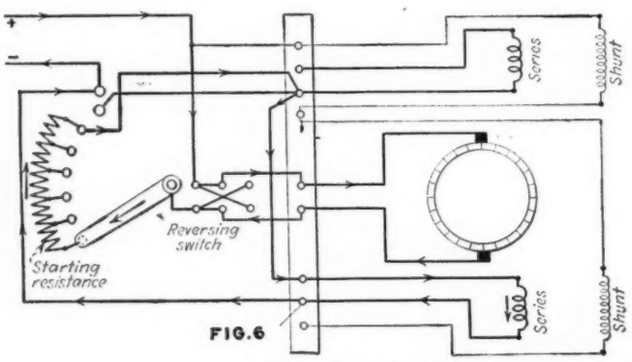


FIG. 6

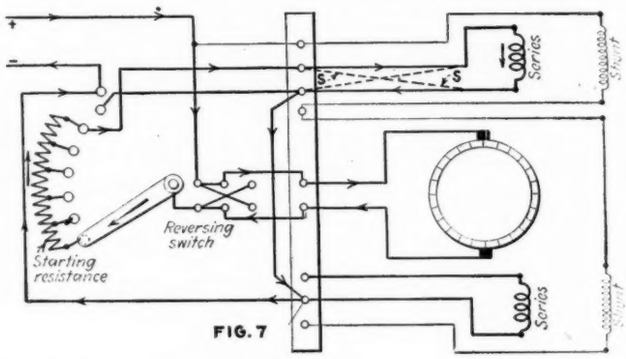


FIG. 7

FIGS. 5 TO 7. METHOD OF TESTING FOR POLARITY OF FIELD COILS

develop anything except that the insulation of the machine was in good condition. After making a test for grounds on the controller, it was also found in good condition.

When about to connect up the machine again, it was decided to test the polarity of the series-field winding. The series-field winding being in two sections, there were three conditions that might exist when the two sections were connected in series: (1) Both sections of the same polarity as the shunt, this being the correct connection; (2) both sections having opposite polarity to that of the shunt; (3) one section having the same polarity as the shunt coil on the polepiece with it and the other section having opposite polarity to its shunt coil. To test for the correct polarity of the field coils, the two wires from the controller to each section of the series winding were connected together as in Fig. 5, and the armature and shunt winding connected up as originally. Then with the connections shown in the figure and the starting resistance arm tied down so that the motor could not speed up, the machine was started and the direction of the motor and position of the controller noted.

The next move after stopping the motor was to disconnect one side of the shunt-field winding and connect in one section of the series winding as in Fig. 6. When the controller was again thrown to the same position as before, the motor was found to turn in the same direction as with the shunt winding, showing that this section of the series winding had correct polarity. After the motor was stopped, this section of the series winding was cut out and the other section connected in as in Fig. 7, and the motor again started by throwing the controller to the same position as before. This time the armature turned in the opposite direction to the other two tests, showing that this section of the series winding had the wrong polarity. To correct this trouble, all that was necessary was to cross the leads coming from the coil to the binding posts, as indicated by the dotted lines *S* and *S*. This rectified the trouble and accounted for the deflection of the voltmeter needle, the latter being due to the transformer action between the series and shunt field winding when the former was cut out of circuit. It was also found that every once in a while the controller arm did not go up far enough to cut out both sections of the series winding. The section left in the circuit was the one that opposed the shunt winding, causing weakening of the field and an increase in speed.

The next test that was made was for a short-circuit between the series- and shunt-field windings. This was done by disconnecting the motor from the controller and bringing a circuit from the line through two lamps and connecting the voltmeter in series with one of them. Lamps were connected into the circuit only as a safety measure against causing a short-circuit on the test leads. One test lead was placed on a shunt-field terminal, and the other lead was touched to a series-field terminal, as indicated in Fig. 4. After making contact with each series-field terminal in succession, no deflection was obtained on the voltmeter, indicating that the insulation between the two windings was in good condition. A test for grounds was made by connecting one side of the test circuit to the frame of the machine and touching the other lead to the motor terminals in succession, and in this case no deflection was obtained on the voltmeter. It might be added here that the test leads should be connected together before the test, to make sure that the circuit is alive. These tests did not

This experience definitely shows the necessity of being careful in accepting the results of tests without first carefully analyzing them.

Foundation Bolts for Steam Engines

By W. H. WAKEMAN

THE first engine installed in my plant was a 14 x 36-in. Putnam, and when it was delivered a granite foundation stone came with it. This stone is 19 ft. 3 in. long, 3 ft. 2 in. wide, and about 19 in. thick; the lower side was left rough in order to give it a better hold on the stone foundation under it. The

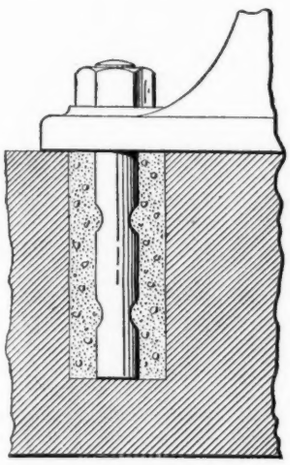


FIG. 1. BOLT SUPPLIED WITH ENGINE

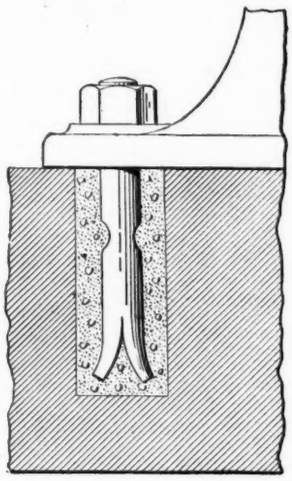


FIG. 2. ANOTHER BOLT HAVING SPLIT END

builder intended to have the engine bolted to this stone only, and the bed of cement provided for it, plus the weight of the stone and the engine were to hold the engine in place. As this is a rather unusual design, it is due the designer to say that it has proved a success for a long time.

Foundation bolts were also supplied with the engine, and one of them is illustrated in Fig. 1 as it would have appeared in working position, but it was not used. Objection to it was because it was round for its entire length, hence if the nut did not turn easily, and caused the bolt to turn with it, there was no way to hold it. Melted lead poured into the hold might grip the bolt, but we were not sure of this result.

Fig. 2 shows a suggested improvement, as the end of the bolt is split and turned outward like a split pin or key. Even this was not considered satisfactory, as it might pull out, and it would then be difficult to replace it.

Fig. 3 illustrates the plan that was finally adopted. The holes, which were already drilled part way through the stone, were carried through, as shown. A pocket was built in the foundation and new bolts were made long enough to take a large washer and another nut.

This bolt possesses several advantages, as there can be no doubt about its holding properties. The top end was finished in a lathe, and it is convenient to adjust the top nut so as to present a better appearance than is possible where the height cannot be adjusted to suit existing conditions. The nuts can be tightened at pleasure, or the whole easily removed whenever it becomes necessary or desirable to do so.

These advantages are especially appreciated by engineers in charge of engines that are loose on their foundations, with bolts and nuts that cannot be tightened to prevent the frames from moving. Such engines are frequently located in plants where it is difficult or impossible to have repairs made or worn-out parts replaced. A slight movement of an engine frame at every stroke of the piston may not worry the superintendent, but it may cause the engineer many an anxious hour as to the possible consequences.

Where only a light capstone (or perhaps none at all) is to be used, the bolt illustrated in Fig. 4 is frequently adopted. The principal advantage is that it is a cheap form of construction. It is only necessary to cut a thread on one end of a piece of round iron, then heat and bend the other as shown. If built in properly, it may hold, and it cannot turn, although the nut may be a tight fit.

It may be possible to make exact calculations so that the bolt will be flush on top, but this can seldom be expected, as such a bolt will yield more or less when force is applied. If a full nut is not secured it lacks the desired strength, and if the bolt projects through the nut it becomes necessary to cut it off for the sake of appearance.

Fig. 5 is a much better type of bolt, although it is not expensive. The lower end is bent around a piece of round iron about 8 in. long, as it is not necessary to weld it, and when this is properly built into the masonry, it will prove satisfactory, but accurate adjustments are not possible with it

Fig. 6 is a common stock bolt with a square head. It is possible to secure satisfactory results with it, but it must be built into the brickwork with greater care

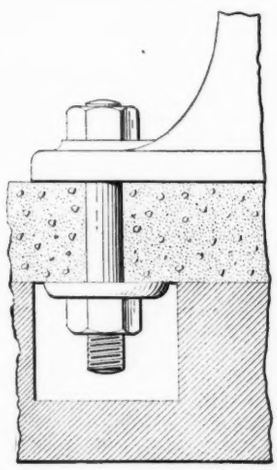


FIG. 3. TYPE OF BOLT FINALLY ADAPTED

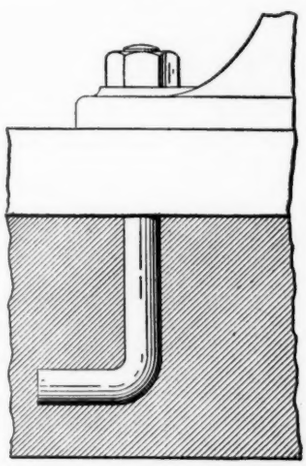


FIG. 4. CHEAP FORM OF ANCHOR BOLT

than the ordinary mason bestows on his job. Bricks must be laid close to the head to prevent it from turning, and nicely fitted above it to afford a good hold.

Foundation bolts are sometimes incased in pipes before being located in place, but there appears to be no special advantage to this form of construction. Such bolts do not hold the engine frame in place by fitting the holes accurately, as this is never considered of value, but by clamping the iron down to the masonry,

therefore only a loose fit in the holes is required. It is not necessary to fill them with cement.

Wooden templets are used to locate the position of the bolts, and these should be maintained until the foundation is finished. If not, the bolts will probably be moved out of place more or less by careless workmen.

Care should always be taken to have these templets set high enough to bring the bolts through the frame when the job is completed. My attention was called to this matter by seeing some foundation bolts that projected only about one-half inch above the cast-iron frame, consequently it was necessary to chip out places for the nuts, thus causing much extra labor, with an unsatisfactory job when finished, as the nuts were only partly filed by the bolts. Of course it is possible to fill the space with putty and paint it over, but that is not good policy, as it gives the appearance of greater strength than really exists.

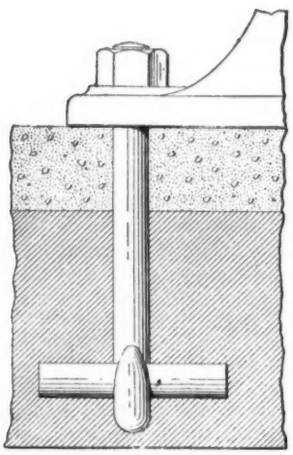


FIG. 5. BOLT WITH BENT BOTTOM END

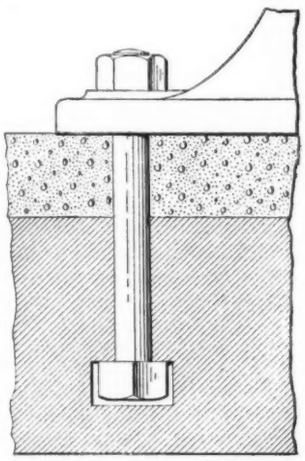


FIG. 6. BOLT WITH SQUARE HEAD ON BOTTOM END

Fig. 7 illustrates a bolt with a square head and a round washer. It gives a good hold in the foundation, but it is possible for both head and washer to turn, if the nut binds on the bolt, and there is no remedy, except to take out a portion of the masonry and rebuild it.

Fig. 8 is much better, as the washer is square and cannot turn in the masonry; a square hole is cast in the washer, thus securing both in place. Care should be taken to have either brick or stone set directly under the bolt head, as otherwise it will drop down when released from the templet. It may seem as if this would be impossible, but all masons are not as careful as they might be, and the fact that they are not to operate the machine after the work is finished, does not tend to give better service.

The following incident illustrates this point: The chief engineer of a certain plant laid out the foundation for a new engine and asked for bids for constructing it. It was to be built of stone laid solidly in cement. When the job was about half finished, he became dissatisfied with the work of the contractor who had submitted the lowest bid on the job. The engineer directed him to mix water and cement together, making the mixture thin enough to freely flow into all crevices, and to pour it into the foundation until it would hold no more. The contractor began to do this, but as barrel after barrel of cement disappeared, and incidentally his profits with them, he announced that he should charge extra for all cement so used. Inasmuch as it was not possible to do more than make a solid job of it, his claim was not allowed. The trouble in all such cases is due to the fact that the mason who calculates to comply with the specifications, does not secure the contract.

Fig. 9 is a good foundation bolt as there is a nut on both ends of it, so that the height can be adjusted at pleasure. The lower one is in a pocket built in the brickwork, and above it a granite stone is located, therefore the stress caused by screwing down the upper nut is distributed over a comparatively large section of the masonry, giving a firm hold accordingly.

Although these remarks on engine foundations may not be considered a part of the subject of bolts for this service, yet the two are closely related, as it is not possible to secure satisfactory service from the best bolts made if they are not located in a first-class foundation.

Even the best of men will sometimes get on the wrong track and spend years in some wild-goose chase. For example, Peter Cooper, the noted philanthropist and engineer of a former generation, somehow got the idea that the combination of connecting rod and crank was a highly inefficient means of delivering the power from the piston to the shaft of a reciprocating steam engine. So he wasted much of his energy in inventing a rack-and-pinion arrangement to drive the shaft. A few facts would have saved him the trouble. If he could have known how small is the difference between the brake and the indicated horsepower of any good engine he would have realized that something was wrong with his reasoning. Even today many inventors are spending valuable time in attempts to solve imaginary difficulties.

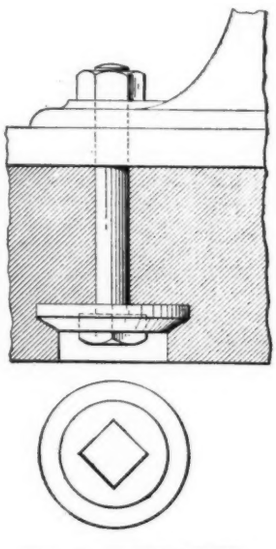


FIG. 7. BOLT WITH SQUARE HEAD, ROUND WASHER

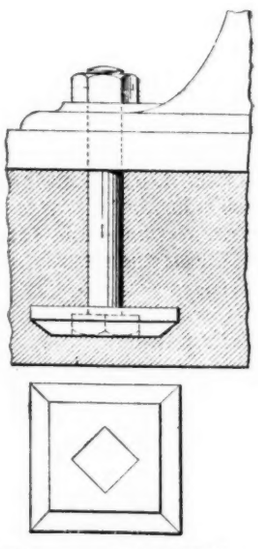


FIG. 8. BOLT WITH SQUARE HEAD AND WASHER

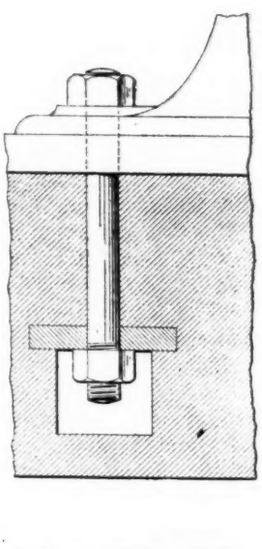


FIG. 9. BOLT WITH NUT ON EACH END

Characteristics of Bearing Metals

Composition of Various Babbitt Metals for Various Kinds of Bearings—A List of Babbitts and their Compounds

By EDWARD T. KEENAN

IN THE earliest machines that our ancestors labored upon, iron to iron for bearings was the practice until some enterprising craftsman discovered that iron to iron for a bearing was not as satisfactory as iron to a softer metal. History does not inform us of the difficulties met with nor just how the decision was reached, but it is probable that someone patched or repaired a worn-out bearing with one of these low-fusing metals and discovered that the patched-up job gave better service than the original. That may have been the birth of what are now called babbitt metals.

While many of the white metals used for bearings are commonly called babbitt metals, it is an error. One Isaac Babbitt, with an experimental turn of mind, made careful research and alloyed a composition that became known as babbitt metal. A composition containing 45½ parts of tin and 1½ parts of copper, 13 parts of antimony and 40 parts of lead was the original babbitt metal and was used for all purposes. Later it was found that no one alloy would give satisfactory service under all conditions, so other forms of "babbitt" metal were compounded.

Light-Duty Babbitt Metal

For light duty babbitt metal was composed of 89 $\frac{5}{16}$ parts of copper, 1$\frac{5}{16}$ parts of antimony, 8$\frac{5}{16}$ parts of lead; and for heavy-bearings babbitt, it was composed of 88 $\frac{5}{16}$ parts of copper, 3$\frac{7}{16}$ parts of antimony, 7$\frac{4}{16}$ parts of lead. Lead and antimony have the property of combining with each other in all proportions without impairing the anti-friction qualities of either. The antimony hardens the lead, and when mixed in the proportions of 80 per cent lead and 20 per cent antimony, no other compound of metals possesses greater anti-friction or wearing qualities or will stand a higher speed without heat or abrasions.

From this have been derived the large number of better or worse bearing metals and substitute babbitts, of which there are only two to be considered, lead-base and tin-base, one having a high percentage of tin, the other having a high percentage of lead. During the war tin became very scarce, as there is practically none mined in the United States. So a search was made to find a substitute for the tin-base babbitt, which was in such popular favor before the war, and it is generally now conceded that the cheaper lead-base babbitts are superior.

Because tin was an expensive metal, it was commonly thought that it is a good alloy for bearing metal in place of a less expensive metal. But tin possessed no lubricating qualities and will stick to and cut the shaft if lubrication is neglected. It was assumed in the past that a bearing to be good, must be hard and the harder the better. And while hard alloys do resist wear, they resist forming to a surface and irregularities in the journal or to foreign bodies such as grit, etc., and immediately begin to cut. With a slight rise in temperature the film of lubricant becomes thinner and thinner and cutting more prominent.

Tests on babbitt metals conducted by a large railroad, show that the rate of wear diminishes with the increase of lead, the rate of wear diminishes with decrease of tin and the alloy containing the least tin and highest lead exhibits the least tendency to give trouble from heating; and that a bearing to be successful, must be sufficiently rigid to support the load, yet not so brittle that it will crack, and must have the necessary yielding or plastic nature as is consistent with its ability to support the load without deforming as a whole.

Bearings Subject to Outside Heat

When bearings are subject to outside heat, the lead-base babbitt is also found superior, for above 35 deg. C. the lead-base babbitt retains its hardness much longer than the tin-base. One large electric manufacturing company uses a composition containing 14 per cent antimony, 78 per cent lead and 8 per cent tin. Some manufacturers replace the antimony in whole or in part with zinc, as antimony and zinc both have the property of hardening lead and tin—as the mixture of lead and tin alone would be too soft to be practical, and while zinc alone would probably constitute the best bearing metal as far as anti-friction qualities are concerned, it has the disadvantage of melting at too low a temperature, and once starting to heat, the temperature rises very rapidly, which puts zinc alone, as a bearing metal, out of the question.

Peening or hammering does not increase the hardness of babbitt. The hardness may be increased by quick cooling of the surface by means of a chilled mandrel.

Babbitt containing 21 to 64 per cent of tin softens at a slightly elevated temperature, so is not so good from the heating standpoint as babbitts of lead base and small percentages of tin.

Deformation Cause of Failures

Bearings fail owing to deformation, therefore hardness, especially at high temperature, is the aim in designating a bearing metal. The standard measuring for hardness is the Brinell test. Tests conducted by the Westinghouse Electric and Manufacturing Co., bring out several important facts. A paper read by Jesse L. Jones at a meeting of the American Institute of Mining Engineers at Milwaukee, October, 1918, gives an account of these tests. Discs 4 in. in diameter and 1½ in. thick were made of the babbitts to be studied and designated *A*, *B* and *C*. They were poured into metal molds and pyrometer leads soldered into the center of each disc.

The composition of the babbitt was as follows:

	A	*B*	*C*
Antimony	8	8½	14
Copper	2	8½	Nil
Lead	Nil	Nil	78
Tin	90	83½	8

At 35 deg. C. the hardness of *A* and *C* were identical, but above this temperature the lead-base babbitt had the greater hardness. A white-metal alloy of any composition will become too soft to support the load if

its temperature reaches around 300 deg. F., and the lower its fusibility the more susceptible it is to the influence of heat and no degree of hardness will protect it. A large electric company after a number of years of testing and experimenting, confirm the superiority of lead-base babbitts, and from these results have adopted a babbitt having the composition under *C* for most classes of machines. Certain bearings like step bearings and thrust bearings give better satisfaction with the harder babbitt *B*. This case is exceptional and only adaptable where the bearing pressure has been high. Good mechanical practice designates 200 lb. pressure per square inch for all ordinary bearings. Where it is necessary to pour a thin bearing or line a bronze sleeve with a thin layer of babbitt a tin-base babbitt should be used on account of its low melting point and better flowing qualities as tin-base babbitts are quite fluid and a large area can be covered with a thin lining.

Lead-Base Desirable

So it may be concluded that of the white bearing metals a lead base is desirable. In deciding on a bearing metal it must possess certain features:

It should be sufficiently rigid to support the load or resist the impact, but yet not so brittle that it will easily crack.

It should have as great a yielding as is consistent with its ability to support the load or resist the impact without deformation of the bearing as a whole.

The ideal structure combines a hard matrix to support the load and a softer metal or alloy contained within such matrix to permit the bearing surface to adjust itself to irregularities of service.

It should be easy to handle in the foundry, machine shop and at the job.

It should be capable of being remelted without deterioration.

For use in babbitt-lined bearings it should be capable of being tinned, so that the babbitt can be applied thereto.

It should have a good heat conductivity in order to dissipate the heat generated by friction.[1]

To fulfill the primary qualifications as outlined, we naturally turn to lead, but as lead is entirely too soft some other metal must be added to give it hardness. The other metal would probably be tin, zinc or antimony, or perhaps a little of all three.

Tin is scarce and has no lubrication qualities. It melts at the low temperature of 449 deg. F.

Zinc has great anti-friction qualities. It is not scarce and melts at 786 deg. F. It conducts heat easily, but heat once started rapidly increases, a quality detrimental to zinc as a bearing metal.

Antimony Melts at Highest Temperature

Antimony requires the highest temperature, 1,169 deg., to melt and has the property of expanding when cooling. It is not easily obtained, though it is always used in type metal combined with lead in proportion of 17 to 20 per cent antimony. Antimony has the advantage over tin in combining readily with the lead and also has the disadvantage in sacrificing ductility.

A tin-zinc alloy known as white brass is popular with some as a bearing metal or babbitt. It acts quite the same as other white metals under the same heat—has a tendency to grip the shaft and crumbles after losing its cohesion. Therefore its successful use is limited to bearings not likely to heat.

Another metal is called copper-hardened babbitt and the term appeals to the imagination as giving relief from squashing trouble. When cold it has most of the properties of toughness and malleability of genuine babbitt, at a lower price. However, it does not possess any special anti-friction qualities. It seldom contains over 2 per cent copper and should never contain over 5 per cent as much copper as tin.

As a guide the following compositions might be cited as satisfactory low-tin babbitts:

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Tin, per cent	8	21.3	5	5	..	10	84	91
Antimony, per cent	8	....	7	10	13	12.5	9	4.5
Copper, per cent	4	3.3	2	..	..	0.5	7	4.5
Lead, per cent	80	12	10	85	87	77	..	...
Zinc, per cent	..	63.3	76	..	..	....	..	...

Nos. 1 and 3 may be used for lining machine-tool bearings. No. 6 may be used for similar service but for greater strain. No. 2 is a popular German "best babbitt." Nos. 4 and 5 are used by railroads for lining car-journal brasses.

Aëroplane and automobile engines will probably continue to require a high-tin babbitt, using 84 to 91 per cent tin, such as No. 7, or if the lining be very thin No. 8 may be required.

High-Tin Babbitt Metal

Tin could best be conserved by confining the use of genuine babbitt to thin shell bearings, which, by reason of the loose play and pounding, make malleability of prime importance. For all other bearings where the linings are secured by recesses, or soldered, or well seated, a well-balanced, properly made lead-base metal, it is maintained, will wear longer, run cooler and give the most economical service.

The foregoing facts as outlined have been gathered from many sources, and I have quoted freely from Kent, and the "Transactions of Mining and Metallurgical Engineers." As in the case of every question, there are always two sides. What I have endeavored to bring out is the fact that in most problems and under the average conditions that we meet there is but little requirement for the high-priced genuine or tin-based babbitts. Considering the arguments set forth and applying them to most bearings, it is concluded that the lead-based babbitt will fulfill practically most demands. However, in instances, a white-metal bearing should be replaced with a bronze bearing, and in some cases the bronze bearing should have a thin coating of the white metal.

Recently, the engineer of a fair-sized steam plant was confronted with a particularly annoying pound in the engine, which was in every respect a high-grade machine, and in reply to an inquiry he stated that he had never had occasion to use an indicator on the engine, although one was in the locker. Connecting the indicator to the engine revealed a bad state of affairs, as it seemed that the engine was doing almost all the work in one end of the cylinder. The uneven steam distribution caused the engine to pound. At the same time the steam consumption was entirely out of proportion to the power delivered. This instance is a striking example of the tendency many engineers have of ignoring the means they possess of checking a plant's performance. Every steam engine, internal-combustion engine, air compressor and ammonia compressor should be indicated at stated intervals. There is no better means of reducing power-plant losses than this check on the cylinder behavior of an engine. Every engineer should own an indicator and should make use of it.

[1] Transactions M. & M. Engr., vol. LX, p. 166.

Power-Plant Accounts—XV. Scrapping Equipment

By WILFRED A. MILLER

THERE is a limit to the conditions under which the original value of equipment may remain in the Investment account, and that is reached when the equipment in question is discarded because its useful life has been spent, or for some other reason. That means that the value at which it has so far been carried must be removed from the Investment account at that time. Another element to be considered is the amount of depreciation or obsolescence that has been written off.

Suppose one of our pumps has to be replaced. Suppose also that it cost $500 and that it had depreciated up to the time of inventory by the amount of $360, so that at that time its value was $140. Also let us suppose that we have written off depreciation to the amount of $80 on this pump since the time of the inventory. Then, if we had an individual Investment account and an individual reserve account for this particular pump, the balance of the former would be $500 and of the latter $360 + $80 = $440, and the present value, as carried on our books, would be $500 — $440 = $60. If the pump is absolutely worthless now, it is apparent that we have not allowed sufficient depreciation on it, since $60 of its value still remains in the ledger. This $60 loss must be entered among our costs in some way or other. Probably the best way to handle it would be to charge it to depreciation for the period.

Generally, the apparatus has some value as scrap. Suppose that we are able to dispose of the old pump as junk for $35. In that event our loss would be only $60 — $35 = $25, and we therefore charge only $25 to current depreciation. Sometimes it may happen that we have applied too great a rate. It should be borne in mind, in such a case, that when so much depreciation has been charged as to reduce the value to zero, no further charge for depreciation of this particular piece of equipment may be made. After that time it will merely remain inert on our books. Any sum received for it as scrap is under these circumstances a clear gain to us. Hence, in this case, instead of making a charge to depreciation we would have to make a credit to it.

In addition to taking care of these phases of the matter, it would be necessary to remove from the Reserve for Depreciation and Obsolescence account the total amount of the depreciation on the apparatus written off against it.

It will now be well to consider the journal entries that must be made when we are called upon to record the facts that have been dwelt upon. As illustrations of the several cases let us assume the examples which follow, in each of which, let us suppose, the cost of the new equipment to replace the old is $1,500.

(1) Reserve = $950; Investment value = $1,000.

A, no scrap value; *B*, scrap value = $30; *C*, scrap value = $50; *D*, scrap value = $65.

(2) Reserve = $1,000; Investment value = $1,000.

A, no scrap value; *B*, scrap value = $25.

It will be noted that (1) represents cases where the Reserve is less than the Investment value, and where the scrap value is respectively zero and less than, equal to and greater than the difference between Investment and Reserve. On the other hand (2) represents cases where the Reserve equals the Investment values and the equipment has or has not scrap value. The journal entries required by these variations are illustrated in Figs. 1 to 6, Fig. 1 showing those for case 1*A*, Fig. 2 those for case 1*B*, and so on. It will be noted that two items are repeated in each entry; namely, a credit entry of $1,000 for the original value of the scrapped equipment and a debit entry of $1,500 for the value of equipment bought to replace it. Moreover, in each of the entries for case 1 (Figs. 1 to 4) there is a debit entry of $950, to remove from the Reserve for Depreciation and Obsolescence account the amount of the depreciation written off against the equipment that is going to be scrapped. Likewise in the entries for case 2 (Figs. 5 and 6) there is an entry of $1,000 of the same nature. The only entry other than these in Fig. 1 is the debit for $50. This is the charge that must be made to depreciation in order to compensate for the amount by which the value written off falls short of the actual depreciation. In Fig. 2 there are two entries other than those common to Figs. 1 to 4, being the $30 credit to surplus and the $20 debit to depreciation. These require a little further analysis. Since the reserve for the apparatus falls short of its original value by $50 when the time for scrapping it arrives, we are faced with the loss of this difference. However, in case 1*B* the scrap dealer pays us $30 for the old apparatus, reducing our loss to $20. This loss is a charge to depreciation just the same as the $50 loss in Fig. 1, and its treatment therefore offers no difficulty. Why, however, should the $30 be credited to surplus? The facts are these: Before the sale of the old apparatus our account showed that we were worth—so far as this particular piece of equipment was concerned—$1,000 — $950 = $50. That is, we possessed $50 worth of machinery. After the sale we had no machine any more, but we did have $30 in money. In other words, we had transformed machinery into money, but we were poorer by $20 because we could not get as much money as we thought we had machine. If we had received as much, then we would have been just as rich after the sale as before, except that our wealth would have been in money instead of in machine. To record this in our books, we will have to transfer part of the Investment account to some other account. The Surplus account serves this purpose since it is in effect a record of what we are worth aside from the value of our equipment.

This is the fifteenth of a series of articles written in conversational style and treating the subject of power-plant accounts in a thorough, yet simple manner. They were prepared primarily for the guidance of the operating engineer who wishes to keep track of the cost of the power he is making, but who knows nothing at all about bookkeeping. Others may find the articles helpful in clearing up their ideas on the subject. This installment shows how to handle transactions that may occur in scrapping old equipment.

In case 1*B* we have transformed into money only part of what we thought the machine was worth, since we thought it was worth $50 but got only $30 for it. Hence, we can add only the $30 to the Surplus account, which we do by crediting that amount to it.

Fig. 3 differs from Fig. 2 in the fact that there is no debit to depreciation, the credit to surplus being $50 instead of $30, because in case 1*C* we are transforming all the book value of the machine into money, not merely part of it as in case 1*B* just discussed. In Fig. 4 we have a set of entries that resemble those in Fig. 2, with the important difference that the entry for depreciation is a credit instead of a debit. This figure records the facts of case 1*D*, in which we find that we receive $15 *more* in money for the machine than we thought it worth according to our books, because we got $65 for it when it was carried at only $50.

In Figs. 5 and 6 we are not called upon to consider any losses, because they represent cases 2*A* and 2*B*, in which the machine has been depreciated to the extent of its entire value. Hence, in Fig. 5 we are called upon to record nothing but the wiping out of the investment and corresponding reserve value, and the arrival of the new apparatus. In Fig. 6 depreciation is credited with the $25 received as the scrap value of the old apparatus, just as is the $15 in Fig. 4, because we should not have depreciated it as fast as we did; there should have been $15 worth of it left on the books, since we were able to get that much for it.

Before leaving the subject of adjusting entries, we shall have to consider those made necessary by the inauguration of a monthly closing schedule. So far we have been arriving at entries for the Total Cost account by transferring to it every month the amounts for the period accumulated in the various direct and indirect expense accounts, without making any notations in the latter, thus leaving it open to question whether or not the balances of those accounts should be taken in conjunction with that of the Total Cost account. To overcome this objection, it was decided to adopt the monthly closing scheme, but before that can be put into practice it will be necessary to dispose of all the balances at the present time standing in the individual expense accounts in order to bring these into the same state as that in which they would be if the policy of closing had been in vogue from the beginning. Really, all that is required to accomplish this is to reduce each of them to zero, since that would be their state. To do this it is merely necessary to look up the balance of each account and then make a journal entry of the amount as it exists at the end of the preceding month, but to the side opposite to that on which the balance happens to be.

This would bring the two sides of the account to the same amount; that is, would bring them into balance. We could therefore rule them off in the manner explained elsewhere in describing the process of closing. Then, starting with the current month, we could continue our entries in the regular way.

Investment	Equipment scrapped			1000	–
Reserve for Depreciation and Obsolescence	Equipment scrapped	950	–		
Indirect Expenses	Depreciation not charged	50	–		
Investment	New equipment	1500	–		

FIG. 1. JOURNAL ENTRIES FOR CASE 1*A*

Investment	Equipment scrapped			1000	–
Reserve for Depreciation and Obsolescence	Equipment scrapped	950	–		
Surplus	Scrap value of equipment scrapped			30	–
Indirect Expenses	Depreciation not charged	20	–		
Investment	New equipment	1500	–		

FIG. 2. JOURNAL ENTRIES FOR CASE 1*B*

Investment	Equipment scrapped			1000	–
Reserve for Depreciation and Obsolescence	Equipment scrapped	950	–		
Surplus	Scrap value of equipment scrapped			50	–
Investment	New equipment	1500	–		

FIG. 3. JOURNAL ENTRIES FOR CASE 1*C*

Investment	Equipment scrapped			1000	–
Reserve for Depreciation and Obsolescence	Equipment scrapped	950	–		
Surplus	Part of scrap value of equipment scrapped			50	–
Indirect expenses	Depreciation overcharged			15	–
Investment	New equipment	1500	–		

FIG. 4. JOURNAL ENTRIES FOR CASE 1*D*

Investment	Equipment scrapped			1000	–
Reserve for Depreciation and Obsolescence	Equipment scrapped	1000	–		
Investment	New equipment	1500	–		

FIG. 5. JOURNAL ENTRIES FOR CASE 2*A*

Investment	Equipment scrapped			1000	–
Reserve for Depreciation and Obsolescence	Equipment scrapped	1000	–		
Indirect Expenses	Depreciation overcharged			25	–
Investment	New equipment	1500	–		

FIG. 6. JOURNAL ENTRIES FOR CASE 2*B*

It was recently pointed out, by Victor J. Azbe, that a constant CO_2 of a given amount was better than a varying CO_2 that averaged the same. This is easily seen by taking a specific example. Suppose in one case the CO_2 is constant at 10 per cent, while in another it is 5 per cent half the time and 15 per cent the other half, so that the average would be 10 per cent as before. If the flue-gas temperature is constant, the flue loss is practically in inverse proportion to the percentage of CO_2. On this basis, if the flue loss at 10 per cent CO_2 were 25 per cent, that at 5 per cent CO_2 would be $\frac{10}{5} \times 25 = 50$ per cent, and that at 15 per cent CO_2 would be $\frac{10}{15} \times 25 = 16.67$ per cent. The average of 50 and 16.67 is 33.33. So it is evident that while both cases would show the same average CO_2 of 10 per cent, one would correspond to a flue loss of 25 per cent and the other to a loss of 33.33 per cent. The case quoted is extreme. With fairly constant CO_2 the difference would not be important.

EDITORIALS

Why Not More Designers?

IN DISCUSSING engineering education at the recent A.S.M.E. meeting, F. C. Pratt lamented that so few graduates of technical schools follow the field of design. This, in his opinion, offers a promising future for the young engineer.

To be a successful designer one must combine temperament, technical training and the requisite shop experience. The proper temperament is a matter inherent with the individual. As for training, the fact that many of our prominent designers received their education abroad may be significant, for it is generally recognized that foreign universities lay more stress upon mathematics and theory. Moreover, to many the shop experience opens up other more attractive lines of endeavor, such as production work and industrial engineering.

Aside from these considerations, however, probably the greatest factor militating against designing as a career is the lack of monetary appreciation on the part of the manufacturers themselves. They have placed a premium upon commercial engineering, which accounts for so many forsaking the field of pure engineering for the more lucrative industrial and commercial occupations.

The remedy lies apparently with the manufacturers themselves.

Information Wanted

HOW much power can be expeeted from an engine of a given size, run at a given speed and with given conditions of initial quality and pressure of steam and of back pressure?

All the factors necessary to a positive answer are present, except the mean effective pressure.

The theoretical mean effective pressure for a given point of cutoff or ratio of expansion is easy to compute. The ratio of the mean effective pressure measured from the actual diagram to that of the ideal diagram for the same condition is called the "diagram factor."

What are the diagram factors of modern engines, with modern pressures, more or less superheat, etc.? A compilation of these values for typical engines would be interesting and valuable. *Power* wants to collect and compile them and appeals to its readers for the necessary facts. If you cannot send the diagram factor of your engine, please send us a good indicator diagram from it with the following information:

Type, size and speed of engine.

Clearance of engine.

Pressure and quality (if known) of steam at the throttle valve.

Degrees of superheat.

There is also need of a comprehensive table of engine efficiencies. Many of these are available in published tests. Perhaps some of our readers have collections or compilations of them. If those which have passed through this office had been compiled, they would have made a valuable collection—but they were not. We shall be thankful for information which you can send us regarding the steam consumption per indicated horsepower of your own or other engines of which you know, with the initial pressure and condition, as to moisture or superheat, of the steam, the back pressure or vacuum, the type, size, and speed of engine, and whatever conditions would bear upon its steam rate. If the steam consumption per kilowatt-hour is available and the indicated horsepower is not, we can use it in that form, especially if some idea of the mechanical efficiency of the engine and the electrical efficiency of the generator is to be had.

Thank you.

The Present Patent Office Situation

THE founders of our country regarded a patent system as of great importance. They provided for it in the Constitution. At first, and for a considerable number of years, patents were granted by the President of the United States in person, assisted by members of his Cabinet. Thomas Jefferson, as Secretary of State, with the assistance of the Secretary of War, passed upon the utility of the inventions and the Attorney General certified as to whether the Letters Patent were conformable to law, after which George Washington signed them as President of the United States.

Our patents were always granted only to the original and first inventor of the invention, but did not make their fullest appeal as an incentive to develop inventions until they were granted only after an examination of the prior art as to novelty. Such an examination gave them a prima facie presumption of validity, and put the burden on an infringer to disprove the validity. This made investments in patents much safer, so that they were more readily sold or capital more easily induced to invest in them, thus making the inducement to invent much stronger. This incentive brought about such frequent efforts to invent as to result in so general a development of the inventive faculty as to make it comparatively common throughout the United States. This has placed us foremost among the nations, both in agriculture and in manufacturing.

When our patent system was introduced, agriculture was conducted manually, with tools which were not only guided by the operator but were driven by his exertions, excepting only crude forms of the plow and the harrow. Today, the farmer so largely uses either automatic machinery or machinery which needs only to be guided by hand that agriculture is substantially on a manufacturing basis. One man today can do from ten to fifteen times the amount of work which he could have performed at the time of the Declaration of Independence. Europe would have starved during the Great War if the American farmer had suddenly been deprived of the products of American invention.

In manufacturing, advances have been even more wonderful than in agriculture and our methods of pro-

duction have been made so efficient and economical that we are able to pay wages that enable labor to live on the best scale in the world.

In 1848 the salaries of Patent Office Examiners were fixed at the same figure as those of United States District Judges and Members of Congress, namely, $2,500. The Chief Justice of the United States then received $5,000. Today the Chief Justice receives $15,000, the District Judges from $7,500 to $10,000, and Members of Congress, $7,500 with perquisites, while the Patent Office Examiners still receive only ten per cent more than the original $2,500.

An examiner must have a college education or its equivalent, but he cannot give his boy the education that would be necessary for him to follow in his father's footsteps. The examiners are required to be both scientifically and legally trained—a double requirement—and those who are competent can derive so much higher income from the practice of patent law outside of the Patent Office that a continuous stream of resignations has been taking place, and less than half of the present force has been in the Patent Office long enough to have had any adequate training, and much of their time is taken in training the recent appointees making up the other half.

The Patent Office is so far behind in its work that if it should refuse to receive any more applications for patent, until it had disposed of what is now before it, it would not receive any more applications for three years. It is utterly impossible for the Patent Office to do good work under its present handicaps, and the result is that a very unnecessarily large number of defective or imperfect patents are being granted, which means large loss to the Government in court expenses and the public at large in costly and unnecessary litigation.

The Lampert Patent Office Bill, H.R. 7077, which has been prepared to remedy the situation, provides for increases in salaries and numbers of examiners which are the least that will remedy the situation, the salary of the Primary Examiner being placed at $3,900, and provides funds for paying the increases by increasing the fees for patents to the extent of $5. The Patent Office has always been self-supporting, and would continue to be so under the Lampert Bill, and Congress should at once pass the bill. The Lampert Bill is successor to the Nolan bill which failed at the last session of Congress solely because of the presence of an objectionable rider having no relation to the Patent Office, and which is not in the Lampert Bill.

If the Patent Office is allowed to go to pieces—and it surely will unless prompt relief is given—we will lose the advantages which it has given us over other countries, for other nations have been strengthening their patent systems while we are letting ours deteriorate.

The Lampert Bill is ready for the vote of the House of Representatives. Every engineer and manufacturer and patriotic citizen should let his member of Congress and Senator know that he wants and expects immediate action in passing the Patent Office Bill, and should ask that they demand of the floor leader of the House that the bill be brought up for a vote.

The Patent Office Committee of the American Engineering Council under the leadership of its chairman, E. J. Prindle, has been untiring in its efforts to relieve the patent situation and its efforts should receive the backing of every engineer.

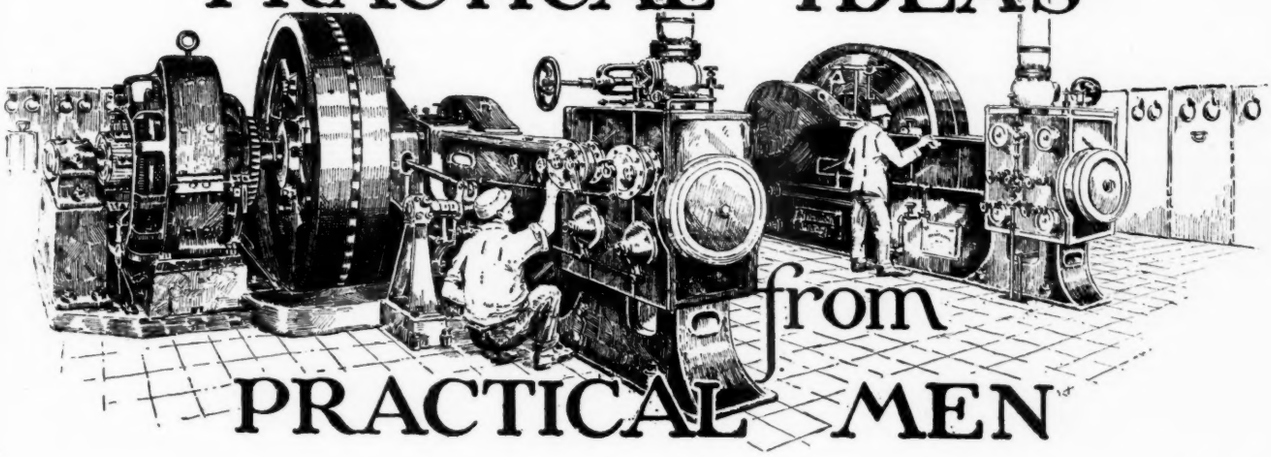
B.t.u. Versus Dollar Efficiency

ABOUT fifteen years ago the steam turbine began to make rapid progress as a prime mover, and with practically each succeeding important installation a reduction in water rate would be recorded. Almost coincident with this development far-reaching improvements in the other equipment in the power plant were made. Steam pressures and temperatures kept increasing until in 1916 and 1917, pressure approaching three hundred pounds began to come into commercial use with total temperatures well up to seven hundred degrees Fahrenheit, and boiler pressures of five hundred and six hundred pounds were being talked of. In fact, some authorities at that time were of the opinion that it was only a matter of a few years when these pressures would become general commercial practice in large power plants. Along with these developments, improvement in condenser design and auxiliaries made it possible to obtain very high vacuums. All these improvements succeeded in bringing the water rate of the turbine down to near the ten-point mark per kilowatt-hour. The engineering skill and genius that made this possible will forever stand as a tribute to those who carried forward this development.

However, the experience with some of these plants and equipment made it very clear that it was one thing to design and build a power plant and an entirely different thing to operate it. It was found that these low water rates, although they looked very nice in theory, not only required expensive construction, but also ran the maintenance charges up to a high figure compared with plants operating at more conservative ratings. Conditions brought about by the war have caused the operating companies to consider more carefully what it costs to produce a unit of power at the busbars—to distinguish between B.t.u. efficiency and dollar efficiency. A careful analysis has shown that lowest water rates and highest boiler efficiency do not always mean lowest cost at the feeders. Furthermore, past experiences have shown that these do not always mean high reliability in plant operation. So far as a power supply is concerned cost and reliability are really the only two things that interest the consumer. Conservation of coal is a very desirable accomplishment, but when it must result in increased cost of power the consumer immediately loses interest and begins to look for some means to be relieved of the increased cost. This was the consensus of opinion expressed by a number of the engineers at the session on "Heat Balance in Power Plants," at the recent convention of the A. S. M. E. in New York City. It was evident that further improvement in power-plant efficiency must also mean dollar efficiency and reliability. If higher steam pressures and temperatures are to be used in the future they must not only result in a reduction in heat units per unit output but also in a reduction in cost at the feeders, without jeopardizing the reliability of the station. This is one of the problems that today is facing the designers and the managements of power plants as well as the manufacturers of equipment.

Some of those among the many that were on hand at the Elimination of Waste Session of the A. S. M. E., at two o'clock sharp, the appointed time, wondered if perhaps there were not some waste right at hand in need of elimination, while they twiddled their thumbs for over twenty-five minutes waiting for things to start up.

PRACTICAL IDEAS from PRACTICAL MEN



Passing of the Old-Time Power Plants

I wonder how many people, when taking a seat in a trolley car or turning on the switch to light an electric lamp, ever pause to think of the source of the energy that enables them to arrive at their destination so much more quickly than in the old horse cars, or of the bulb that gives so much more brilliant light than the smoky oil lamp or sputtering gas jet? Not many, unless it is occasionally one who may have had something to do with the generation or transmission of electric energy.

Back in the early 90's, when street-car lines were being electrified and electric light lines were being extended, small and medium-sized plants were to be found all over the cities; one would often see an ice-making plant running in connection with an electric-light station, to utilize the exhaust steam.

On the west bank of the Bronx River, at the foot of 172d St., New York City, stands a large, substantially built red-brick building, its walls weather-stained by 30 years' exposure. Its 160-ft. smokestack is still reared defiantly to the sky. Under its high, monitored roof 5,000 hp. of electric current could be generated, and from it every trolley car north of the Harlem River and as far as Mount Vernon and New Rochelle got its power.

That was considered a representative up-to-date plant in those days. Erected in 1892, the plant consisted of eleven water-tube boilers, six tandem-compound Corliss condensing engines, belted to multipolar generators. Later, a 2,500-hp. cross-compound Corliss engine and engine-type generator were added. I remember that the armature had to be brought from the railroad station on rollers and the bridge at West Farms reinforced to sustain the weight; and it was the wonder of the neighborhood.

When the big Kingsbridge plant was put in operation, the Bronx business was taken over, as the big central stations have taken over the load of nearly all the rest of the old plants. The Bronx plant was shut down, the machinery was sold for manufacturing purposes or scrapped, and the place is only a memory and a landmark of other days.

I stood at the gate of a large junk-yard in West 14th Street one day and watched a wrecking outfit make scrap of a large Corliss engine. No doubt our nickel car fares and kilowatt-hour taxes had paid for it many times over, but it seemed a shame to destroy in a few minutes such a noble-looking machine, which had taken many weeks of painstaking thought and mechanical skill to construct.

It is a far cry from the old-time power plants to the big modern central stations, with their turbine engines of thousands of horsepower and high-tension current that can be transmitted many miles. I take off my hat to them.

M. M. BROWN.

Camden, Me.

Difference Between Estimated and Operating Figures

After changing a power plant over to central-station service, the plant was left with two 3,500 sq.ft. water-tube boilers, and 27,263 sq.ft. of radiation, owned by three separate owners, 8,282, 8,127 and 10,854 sq.ft. respectively. One was a dry-goods store and the other two buildings were rented for light manufacturing. The question was, How much should be charged for steam for heating after the change?

The owner of the power plant, who also owned one of the buildings, got together a list of prices from different heating stations, which ranged from 85c. to $1.50 per 1,000 lb. of steam, with all kinds of variations and sliding scales to suit the price paid for coal, but none of them suited this plant.

Each property owner said he would get a heating expert to look out for his interest and try to decide on a fair price. The first one reported that 75c. per 1,000 lb. of return condensation was sufficient to charge. The next said $1.19 was the price that should be charged, and the third said $1.63, allowing 10 per cent profit and figuring the cost of the plant on pre-war prices. The third expert was hired by the plant owner and came highly recommended as a heating man. There was such a difference in the estimates that the plant owner did not know where he stood.

Finally, the three owners decided to run the plant on a cost plus 10 per cent basis, and $1.50 was to be charged per 1,000 lb. of condensation per month until the end of the year, when a distribution or a collection was to be made based on the percentages of radiation in the buildings and condensation. Meters were installed on the returns from each building.

It was looked upon as a satisfactory agreement and a steam saver, as each owner said that he would see to

it that no steam was wasted. The dry-goods man preferred to have his store cool for his customers' sake who came into the store wearing street clothing, and advised his clerks to wear sweaters or heavy clothing. The floors used for manufacturing required but little steam after the wheels were going. The routine was to turn on steam at 6 a.m. until about 10 o'clock and again for about an hour in the afternoon. All the shops worked 48 hours a week. For about four months out of the seven months of heating, the boiler was run about five hours per day and banked for the other nineteen hours.

An accurate account was kept of all the expenses and 777 tons of soft coal and 600 tons of screenings, a total of 1,377 tons, were used; 11,161,000 lb. of water was registered on the return meters, or about 4 lb. of water per pound of coal; this takes into account the coal used for banking. Coal averaged $10 a ton. On July 1 the books were made up, and it was found that it had cost $28,000 to run the plant under the new arrangements, figuring in the overhead. The cost per 1,000 lb. of condensation was $2.50, which was much higher than the experts' figures. The cost per square foot of radiation was $1.03, which looks reasonable, because of the high price of coal and the low load factor. The plant was valued at $75,000. THOMAS SHEEAN.

Springfield, Mass.

Explosions in Open Feed-Water Heaters

Miniature explosions in open feed-water heaters may occur many times a day without the operator noticing it. These explosions may be caused by the heater not being vented, high-pressure bucket traps discharging into the heater, inrush of cold makeup feed water, water building up on top of the atmospheric relief valve, and in fact, any sudden small change of temperature or pressure. In one instance the cause was found hundreds of feet away from the heater.

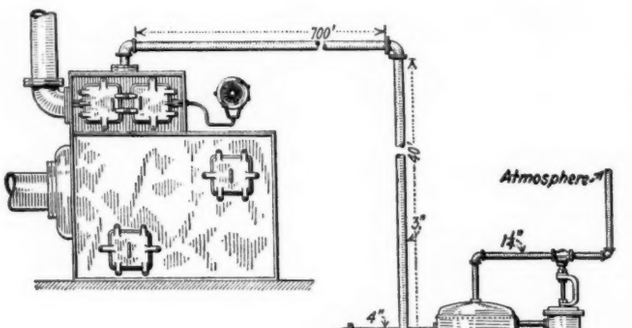
Our heater pressure charts showed that explosions were occurring in the heater. It required a search of weeks to locate the cause. We were running with an open heater in service and every now and then the flow-meter cables would jump from their drums, apparently without cause. One day I decided to watch the flow meter attached to the heater, and all at once there was heard a splash and rattle in the heater, the meter cable jumped its drum, and the water level was seen to be surging up and down.

Shortly afterward the heater was cut out of service for internal inspection, but everything was found the same as when installed. When it was put back in service, it was as bad as before. There was a back pressure gage on the exhaust inlet to the heater and one on the outlet side. I watched these gages, and when the disturbance occurred again, the gages did not register.

A back-pressure recording gage was connected to the heater, and the charts showed fluctuation of pressure other than normal, which indicated that sudden changes in pressure or temperature were the cause. The heater was vented with a one-inch line, but the explosions were there.

We next disconnected the high-pressure trap return, but the explosions continued. The cold-water makeup feed was next cut out, but the heater still kicked up a fuss. A close watch of the recorder pin showed that it would first drop below and then shoot above the normal pressure line. This suggested that the incoming water acted as a jet and condensed steam within the heater, causing a vacuum that was followed by an explosion. We then put a vacuum breaker in the shape of a 1½-in. swing check valve on the heater. When the heater was under pressure the check would close, and when a vacuum started to build up the check would admit air, thereby breaking the vacuum; but the explosions still occurred and we tried everything in the plant in an endeavor to check them.

The nearest building to the power house was two hundred feet distant, and it seemed impossible that the cause could be that far away. Still the search had to be conducted, and the cause of the trouble was finally located seven hundred feet from the heater, where a little air trap was discovered and was found to be the trouble maker. It was at the lowest point of the plant, which covered ten acres, and all the returns were drained to that point, where a vacuum pump picked up the water and air and discharged it into a closed tank at the top,



SHOWING HEATER AND PIPING CONNECTIONS

the water leaving the tank at the bottom and rising forty feet on its way to the heater. The connection formed a water seal, and all air that accumulated in the tank was released to atmosphere by a float trap; as the air increased, the water level dropped and the float in turn opened the valve to the atmosphere, thus releasing the trapped air.

A gage glass was installed on this tank, and at times the water level would rise or fall. The changes in the water levels were timed and checked with marks on the recording chart, and for each drop of the water level an explosion occurred in the heater.

To assure myself that the cause of the trouble was at last found, I stopped the vacuum pump for half an hour at a time when the explosions in the heater were recording every few minutes. A straight line was made on the chart for the half hour the level in the tank did not change. A 3-in. check valve was placed in the line between the heater and the tank, and all explosions ceased as shown by the clear charts thereafter obtained.

All the experts have gone, leaving an open argument. The sketch shows the layout, and I would like to have someone come across with a final explanation of conditions before and after the check valve was introduced.

Canandaigua, N. Y. R. MILLER.

CORRESPONDENCE

Valves in Water-Column Connections

In reference to Mr. Arrell's experiences, page 733 of the Nov. 8 issue, I will say that I agree with him in every detail of his argument that such valves may become of help in such emergencies as he mentions. However, he has much to be thankful for that he went through this experience in a few hours without any serious loss, and if the fireman is blamed with the mishap of breaking off a blowdown pipe through carelessness, is it not also likely that this same fireman might be as careless as to shut off the column valves if they had been in the connections, and thus probably burned and ruined the boiler so that the loss would have been serious and the boiler put out of service for weeks instead of a few hours.

In a recent paper read before the N. A. S. E. Local No. 7 by a boiler-insurance inspector, complete data regarding boiler accidents of the year of 1920 revealed that several boilers were ruined, and some so badly that they had to be sold for scrap, because the valves had been closed in the water-column connections.

So far as "boneheads" are concerned, and Mr. Arrell admits that some "bonehead" may close the valve and cause a burnt boiler, and the world knows that boneheads are almost as abundant as grasshoppers in season, it is necessary for the insurance companies to take all possible precautions to guard against them. If valves are to be used in column connections, they should be bolted in an open position in such a way that it is necessary to saw the bolt to close the valve, or locked with a padlock and the key thrown away so that the lock will have to be broken to close the valves.

With reference to the broken blowdown pipe I do not think the fireman is to blame, as it would take a pretty heavy clinker hook or a deliberate blow to break off a substantial pipe. I realize that such a mishap is likely to follow, and I have just such faulty conditions in my own boiler plant. I realize this and have considered making alterations, but admit that I have neglected to make the proper change that has been anticipated, yet these changes are in line of repairs to be made.

The probable cause of the blowdown pipe being broken was, as I have found in practice, that the condensation which one can see trickling down the glass gage and which also condenses in the water column, settles to the bottom and stands in the nipple between the blowdown valve and the bottom connection, where also settles alkaline sedimentation, thus corroding the nipple until it is thin and in a weakened condition and likely to break with a moderate blow.

The blowdown pipe from the water column should be provided with a blowdown valve in easy reach of the fireman and an emergency valve just below the column connection. The lower valve may be a ¾-in. renewable-disc type and the upper one a 1-in. valve connected with a double-strength copper or brass nipple, the blowdown pipe being ¾-in. and connected into the 1-in. valve with a brass bushing. The ¾-in. pipe will break before the heavy copper nipple, and there remains a way to shut off the blowdown pipe while putting in a new one.

An incident reflecting on a careless fireman occurred in a plant where there were several water-tube boilers, equipped with automatic feed-water regulators, high- and low-water alarms and fusible plugs. The feed-water regulators had to be watched and repaired frequently. One day one of them failed to control, and the water crept up until the high-water alarm sounded. One of the two firemen on watch blew down the water column and coincidentally with this blowing down it happened the alarm float was broken off the rod, rendering the alarm inoperative. The fireman, realizing there was too much water in the boiler, shut off the feed valve without reporting anything wrong with the regulator, and the two firemen seated themselves to chat without further thought of the water trouble.

The water lowered until the low-water alarm should have responded, but it failed owing to the broken float rod. The water kept getting lower and the firemen kept on chatting. Eventually, something was heard blowing in the furnace, and they awoke to the fact that they had closed the feed valve nearly an hour before and the fusible plug had blown.

This incident goes to show how automatic safety devices can fail and how firemen who become dependent on such devices soon become brainless to the performance of their duty. In the event that the fusible plug, or last resort in safety appliance, had failed, there would have been a badly damaged boiler if not a more serious accident, and the engineer would have been blamed.

Evansville, Ind. CHARLES B. RISLEY.

Eddy Troubles in the Flumes of Hydraulic-Turbines

In *Power*, Aug. 30, 1921, Andre Landry published his experience with a hydraulic turbine placed too close to the headrace water level. The correction of the trouble is surely of great interest to hydraulic engineers who have been confronted with this or similar problems. The writer met with a similar trouble, and as the conditions are slightly different and also the elimination of the trouble, it may be of interest to some readers.

The arrangement of the flumes as shown in Figs. 1

and 2 had to be resorted to on account of lack of room for the power house. The runners are 61 in. in diameter (same type as 30-in. runner, Holyoke Test 1796, *Trans.* A. S. C. E. 1910, by C. Larner).

As can be seen from the figures, the two turbine flumes Nos. 1 and 2 were intended to act as an open scroll which they did not do, while No. 3 was placed centrally in the flume and has caused no extraordinary trouble. The output of unit No. 3 is 540 kw., while that of Nos. 1 and 2 is only 525 kw. when no eddies exist. The deficiency is undoubtedly due to the different setting.

For years the main bearings and bushings in the crown plate of turbines Nos. 1 and 2 wore every week about ¼ in. on the diameter and had to be taken out and replaced weekly, at an expense of over $1,000 a year.

This wearing was due to the main turbine bearings being undersize in their initial design and lubricated

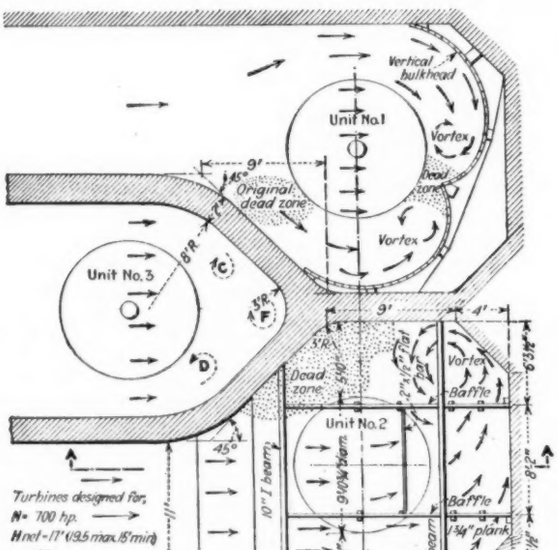


FIG. 1. PLAN AND ELEVATION OF TURBINES AND FLUMES, SHOWING HOW EDDIES WERE OVERCOME

with grease. In cold weather it was impossible to squeeze the grease through the lubricating pipe, and a heavy oil was used with little success. In order to correct the trouble, I designed an adjustable lignum-vitæ bearing (which in its details presents nothing new) with water lubrication from the city mains.

In making this change, I found what I believed to be the chief source of the trouble: namely, a heavy eddy in one corner of flumes Nos. 1 and 2. The water-flow lines are indicated in Fig. 1 (flume 2), showing the vortex and the dead zone where a stagnation of the water existed.

The eddy opened periodically only when operating the turbines at full gate and maximum head (18 to 19.5 ft.), which means the maximum draft of water. This must have caused a strong and eccentric force that rocked the entire turbine, as all the staybolts were

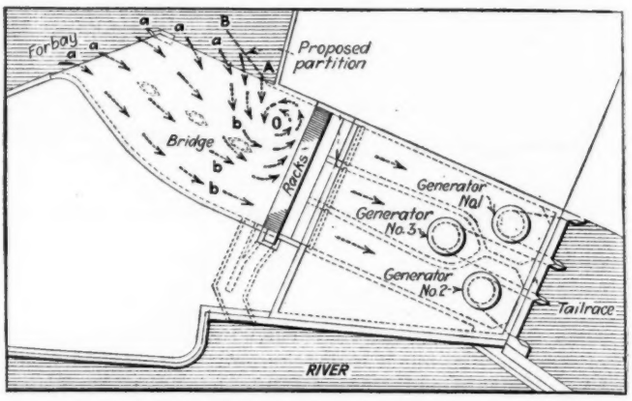


FIG. 2. SHOWS WHERE EDDIES FORMED IN INTAKE

found to be loose so that the casing could be rocked by one man. Whenever the vortex formed and opened up, air was sucked through the wicker gates and runner, frequently breaking the water column in the draft tube, which was accompanied by vibrations, a heavy roar and a drop in power of about 75 kw., as was indicated by the switchboard instruments. This disturbance continued until the eddy closed up again, the entire disturbance lasting 15 to 30 seconds. No serious electrical operating troubles have been experienced, as the units are connected to a large power system.

A float, or raft, as mentioned by Mr. Landry, was thought of, but when considering the high velocity with which the water ran over the top of the turbine, the application of this method was considered to be out of the question.

The first attempt to break up the eddy and to obtain better flow conditions was the rounding off of the corners in the flume, as shown for Unit No. 1, by means of a vertical bulkhead extending above the water surface and to the bottom of the flume. The result was two small eddies instead of one large one, which, however, did not reach deep enough to cause their extension into the turbine. Also the original dead zone, indicated in flume 2, showed a normal velocity, and better velocities were obtained at all points. A small stagnation existed between the two vortices.

Flume 2 was affected with the same trouble, but a cheaper method was resorted to, which finally gave satisfaction. Two baffle plates were introduced in order to laminate the flume. The proper location in plan was found by trial, placing first the one in the neighborhood of the eddy, then placing the second one and finally shifting the two baffles until the eddies disappeared. Similar baffles were placed in flume 1 containing the bulkhead, causing the small eddies to disappear, and no change was noticed, when finally the bulkhead was removed from the flume.

As mentioned before, the drop of power in units No. 1 and No. 2 due to the eddy was about 75 kw. The force due to the deflection of the water against the baffles appeared to be insignificant, as the 1¾-in. planks

from which they were made showed no sign of deflection nor any appreciable amount of vibration.

Flume No. 3 has caused no particular trouble, although small eddies, starting in *C* and *D*, move to *F*, where they open up and suck air for a few seconds and then disappear, causing the load to drop about 10 kw. and in some cases as much as 50 kilowatts.

In many textbooks and proposal drawings open-flume arrangements are advocated in which the turbine is placed eccentrically in the flume in order to obtain the effect of a scroll case. Also scroll cases open on top are sometimes shown. However, the writer has never seen this actually done nor has he heard or read of any such case being successfully operated. It appears that designing engineers are aware of the danger of eddies and rather choose a closed scroll or place the turbine centrally in the flume. In any open arrangement there is quite a high velocity rushing over the top of the turbine on account of the shorter distance, which velocity, arriving at the end wall, is at right angles to the velocity along the walls, thus inciting eddies.

At the intake of the same plant, when the draft of the water is heavy, a severe eddy is caused at point *O*, Fig. 2. The water in points *a* is at the same elevation as the forebay and enters in the proper manner along the arrows. There is, naturally, a gradual drop of a few inches from *a* to *b*, but not so in the corner at *A*. This difference in head accelerates the flow from *A*, striking the more gentle flow from *a* to *b* at less than 90 deg., thus causing an eddy in corner *O*. The force of the eddying water striking the rack bars directly from the side is so violent that it shakes and rattles them loose in a short time. It also causes a drop of 12 to 15 in. through the racks alone, which, based on 17-ft. head, is 7.5 per cent loss. It is planned to correct this trouble by means of a partition along the line *AB*.

It would be interesting to hear of the experiences in this regard made by other engineers.

Utica, N. Y. C. VOETSCH, Hyd. and Elec. Eng., Utica Gas & Elec. Co.

Heating and Its Relation to Isolated-Plant Operation

The article in the Nov. 15 issue of *Power* entitled, "Heating and Its Relation to Isolated Plant Operation," by E. I. Wilder, treats this subject rather too much from the central-station point of view. Although it is true that the extent to which exhaust steam is actually used for heating is often exaggerated, still the figures given by Mr. Wilder hardly represent the real conditions under which a combined heating and power plant usually operates.

The calculations and curves he shows are based on the assumption that the steam required for heating a building varies as the difference between inside and outside temperature, and the results thus obtained are anything but flattering to the isolated plant. However, this relationship exists only in theory, as it is practically impossible to regulate a heating system so perfectly as to maintain a constant inside temperature in any weather.

A heating system is designed to maintain an inside temperature of, say 70 deg. when the outside temperature is at a minimum. With any higher outside temperature than the one for which the heating surface is proportioned, there is a tendency for the building to overheat. It is true that some radiators will be shut off when this occurs, but in many cases windows will be opened, with the consequence that the amount of steam used will not decrease in proportion to the difference in temperatures.

To take an extreme case, assume that it is desired to maintain a building at 70 deg. with an outside temperature of 50 deg. According to theory the coal consumption under these conditions would be less than 25 per cent of the amount used with an outside temperature of 10 below zero. But it would probably be found that the actual consumption would be about twice this due to the causes mentioned.

It will, therefore, be seen that considerably less exhaust steam will be wasted in moderate weather than shown by the curves given by Mr. Wilder. Even assuming that, say, 30 per cent of the exhaust steam is wasted during the heating season, it is evident that the isolated plant is still a cheap power producer.

With coal at $5 a ton and assuming a steam consumption of 35 lb. per horsepower-hour a steam engine will generate power at a coal cost of about 1.55c. per kilowatt-hour. If two-thirds of the exhaust for this engine is used for heating the building, the net cost of power is only about 0.52c. which is a considerably cheaper rate than that at which most central stations could sell it.

Toronto, Canada. DALLAS F. GRAHAME.

Scratching in a Steam Engine

In a recent issue John Holmquist stated that he was in charge of a plant containing a 75-hp. and a 125-hp. high-speed engine, and that when the load was below 300 amperes or, say, 80 hp., the large engine had a scratching noise in the steam chest.

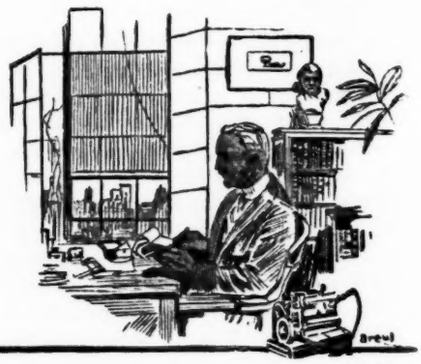
I happen to be familiar with the type of engine in question, which has a pressure ring on the back of the valve. This engine is shaft-governed, and as with similar engines, at low loads the cutoff is earlier and all valve events take place early, including compression. The consequence is that on light loads the exhaust port is closed early, the back or compression pressure rises very fast, and often exceeds the steam-chest pressure at the end of the stroke. This excessively high compression pressure lifts the steam valve a slight amount at this point. The valve is partly balanced by means of a valve ring, preventing the live steam acting upon the entire top of the valve from holding the valve to its seat. The springs are too weak to resist the upward thrust of the valve.

This click or scratching of the valve can be eliminated by either loading the engine more or stopping it and carrying the load on the 75-hp. engine, or by dropping the steam pressure in the boiler from 100 to, say, 70 lb. If the latter is done, the engine will cut off later owing to lower pressure, and the compression will be started later and will not rise above the chest pressure.

Jersey City, N. J. J. CASSIDAY.

The less the amount of excess air—down to the point where there is not enough for complete combustion—the hotter will be the products of combustion. This is due, of course, to the fact that the gases get their heat from the coal and the same amount of heat put into a smaller quantity of gas must raise it to a higher temperature. A hot furnace is therefore one of the indications of good combustion conditions.

QUESTIONS AND ANSWERS



Omission of Counterboring in Cylinders of Pumps

Why are not pump cylinders counterbored the same as engine cylinders? W. F. P.

Engine cylinders are counterbored because the piston in always traversing the same part of the cylinder would wear it away, leaving a shoulder in each end of the cylinder if the piston did not go a little beyond the ends of the main bore. In a direct steam pump the length of stroke is variable from adjustment, change of speed and other conditions, so that counterboring the cylinders to prevent formation of sharp shoulders is unnecessary.

Waste of Steam at Safety Valves

We are troubled with frequent popping of our boiler safety valves and sustain large waste of steam from that cause. How can the boiler attendance be conducted to obviate the trouble? C. A. B.

The waste occurs because the firing is not adapted to the demands for steam, due to unskillful or irregular firing or because there is insufficient boiler capacity to meet suddenly increased demands for steam by drawing on the storage capacity of the boilers and depending too much on regulation of the uptake or stack dampers to take care of the load. The boiler-room force should be informed well in advance of times when there is to be extraordinary demands for steam and how long each period is likely to be continued. When thus posted it becomes the duty of the firemen to provide the boilers with a good supply of water and fresh fires so regulated that they will be burned down when the unusual demands for steam have passed over. It is difficult, however, to prevent loss of steam at the safety valves unless the storage and generating capacities of the boilers are reasonably adequate to meet the demands for steam.

Testing Alignment of Crankpin

How can a test be made to determine if the crankpin of the engine is square with the crank? T. N.

The crankpin cannot be regarded as "square with the crank" unless the center line of the pin is parallel with the shaft. Hence if the shaft is at right angles and the guides parallel with the cylinder center line, the center line of the pin should be square with the guides. To determine whether the pin is "square with the crank," place the crosshead at about one-half stroke, detach the connecting rod from the crosshead, and with the rod end supported above the crosshead, key up the crankpin brasses so the crosshead end of the rod will be nearly supported by the grip of the brasses on the crankpin. Then with the crosshead pushed toward the cylinder to clear the end of the connecting rod, determine whether a point near the end of the rod always falls the same distance one side of the middle of the guides when the crank is placed at different positions of rotation, or in other words, whether for each position of the crank the crosshead could be moved to such a position that the free end of the rod, when swung around the crankpin, always lands at the same place in the path of the crosshead without requiring the rod to be forced to one side. If for any position of the crank the free end of the rod falls nearer to the side of the crank than when the crank is in the opposite position, it is an indication that the crankpin is not parallel with the shaft.

Tests should be made for opposite positions nearly as possible at the dead centers and when the crank is about at right angles with the guides. To make the pin "square with the crank" for that position of each pair which casts the end of the rod toward the crank, the end of the pin farther from the crank should be farther away from the crosshead.

Determining Leakage of Valves of Corliss Engines

In a Corliss engine how can it be determined if there is leakage of the valves? S. N. A.

Leakage of steam valves usually will be shown by indicator diagrams from irregularity of the expansion line, higher terminal pressure than would be due to the cutoff, and excessive leakage may be indicated by abnormally high back pressure. Leakage of an exhaust valve is shown by undue lowering of the expansion line and falling off of compression of the exhaust. A more exact index of steam-valve leakage is obtained by opening the throttle a little and with the engine stopped, noting whether there is an escape of steam from the indicator cock in the same end of the cylinder when the valve is closed with the dashpot plunger seated in the bottom of its dashpot. To test leakage of an exhaust valve, place the engine on a dead center, then unhook the wristplate and with the starting bar admit steam to the same end of the cylinder in which the valve to be tested is located. If there is leakage of the exhaust valve, it will be shown by escape of the steam from the exhaust pipe.

Bulging of Boiler-Tube Sheets

What causes the ligaments of a tube-sheet to bulge outward between the tubes and how can the deformation be prevented? H. K.

More or less bulging of a tube sheet occurs from internal pressure until the tubes and stays are brought

to bearings that offer enough resistance to prevent further deflection of the tube sheet. Some movement of the tube sheet over the original setting of the tubes is inevitable, and there will be additional bulging after each retubing of the boiler. On account of consecutive slippage of the tubes, there is irregularity of bulging that may present the appearance of crimps or bulges between the tubes. The bulging and crimping is less when the sharp edges of the tube holes have been taken off and the tube ends are carefully beaded over. The deformation is more likely to continue with repeated changes from low to high pressure, and if it cannot be satisfactorily checked by uniformly re-rolling and beading over the ends of the tubes, the remedy would be to provide new tubes, or at least new tube ends, set in more carefully prepared tube holes, with the view of obtaining less additional bulging than would occur from retention of the old tubing.

Boiler Efficiency

What is meant by the efficiency of a boiler, and how is the term involved with the efficiency of the furnace and grate? C. R. B.

As ordinarily stated, the efficiency of a boiler refers to the combined efficiency of boiler, furnace and grate as operated. Expressed as a formula,

$$\left.\begin{matrix}\text{Efficiency of boiler,}\\ \text{furnace and grate}\end{matrix}\right\} = \frac{\text{Heat absorbed by boiler per lb. of fuel fired}}{\text{Heat of perfect combustion per lb. of fuel}}$$

This efficiency makes no allowances for moisture in the fuel, imperfection of the combustion, or for loss of coal from dropping through the grates.

The efficiency of the boiler alone as distinguished from the combined efficiency of boiler and grate, expressed as a formula would be,

$$\left.\begin{matrix}\text{Efficiency}\\ \text{of boiler}\end{matrix}\right\} = \frac{\text{Heat absorbed by boiler per lb. of coal}}{\text{Heat actually developed in furnace per lb. of coal}}$$

But in this formula the furnace is not eliminated, for the presence of excess air lowers the efficiency and the amount of excess air depends on the furnace design and operation, and it is difficult to determine the actual efficiency of a boiler alone, as distinguished from the efficiency of the combined apparatus. Hence, in usual commercial practice, the combined efficiency of boiler furnace and grate is used. When guarantees are to be met by a boiler manufacturer, where the boiler and stoker or grate are different installations, the efficiency of the boiler alone should be based on minimum CO_2, maximum CO, and the amount of combustible that is in the ash and blown away in the flue gases.

Chimney for Boiler With Forced Draft

What is the requisite of a chimney for operation of a boiler with a forced draft? C. S. S.

The pressure of the forced draft should be no more than necessary to supply the required amount of air through the fuel bed against a little less than atmospheric pressure in the furnace space above the fire. To maintain that draft condition in the furnace, the chimney must be large and high enough to overcome draft losses in passage of the gases through the setting, tubes, uptake and connections to the chimney. The draft pressure immediately above the fuel bed will thus balance or be a very little below the pressure of the atmosphere.

When the natural chimney draft is so little that sufficient fuel cannot be burned, without so much pressure of the forced draft that the draft pressure in the furnace is higher than the pressure of the atmosphere, particles of cinder and unburned coal are likely to be blown from the thinner parts of the fire and become lodged in the setting and flues, or discharged out of the chimney, and there will be disagreeable discharges of furnace dust and gases from all furnace joints and crevices, or from opening the firedoors. On the other hand, the best results generally are obtained when the chimney draft is so checked that the draft pressure in the furnace is only a very little below the pressure of the atmosphere, showing little tendency to draw an open handkerchief toward the fire when held by the corners before an open firedoor. Under that condition but little cold air is admitted during firing, and with the chimney draft no more than necessary for overcoming friction of the gases in the flues and passages to the chimney, there will be minimum loss of economy from infiltration of cold air through crevices in the boiler setting.

Effects of Reducing Speed of Compound-Wound Generators

I have a 35-kw. 220-volt compound-wound generator which runs at 1,250 r.p.m. This machine is driven through a chain belt, by a 60-cycle 25-hp. induction that runs 1,150 r.p.m. at full load. Although the normal voltage of the generator is 220 it can be adjusted to 300 by the field rheostat. Can the machine be connected directly to the motor and yet generate normal voltage? H. A. R.

No exact analysis can be made of this problem without knowing the characteristics of the machines. However, some considerations may be made that will give an indication of the chances of success if the speed is reduced. If these look favorable, then, since it will not cost very much, the machines can be connected up temporarily and a test made to determine what the actual results will be. The voltage (300) was probably obtained with the machine operating at no load so that the speed of the generator was about 1,290 r.p.m. and not 1,250 r.p.m., consequently the reduction in speed at full load, when the generator is directly connected, will be from 1,290 to 1,150, or 140 r.p.m. Neglecting the effect of the reduced voltage on the magnetic field, the voltage will decrease directly as the speed, therefore at the reduced speed it should be equal to $(300 \div 1{,}290) \times 1{,}150 = 268$. The effect on the fields will probably reduce this value to between 255 and 260 volts. The reduction in speed will also reduce the compounding of the machine. However, if the voltage has been fairly constant under normal conditions, the chances are good for the machine operating successfully under the new condition. If the machine has a shunt, connected across the series-field terminals, its cross-section can be reduced or it can be removed altogether to improve the compounding if necessary. If it is desirable to connect the machine up directly, the indications are sufficiently favorable that the generator will give satisfactory operation at the reduced speed, to warrant a test made with a temporary arrangement.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Remarkable Results with Turbine Blades of Stainless Steel*

British Tests Show Absence of Corrosion and Erosion—Other Engineering Applications Being Developed for Stainless Steel

STAINLESS steel, which is an alloy containing from 12 per cent to 14 per cent of chromium, was discovered at the Brown-Firth Research Laboratories, Sheffield, by Harry Brearley, in1912, and in a report on its properties, written in October of that year, Mr. Brearley suggested its use for the blading of steam turbines.

Several years elapsed before this suggestion was given a practical test. This delay is not surprising, in view of the unsatisfactory results obtained with other materials for which great things have been predicted. It was in 1916 that F. Samuelson, of the British Thomson Company, Rugby, determined to make the trial and, with the consent of one of his clients, used five different kinds of material for the blading of one wheel of a steam turbine. The materials selected were phosphor-bronze, nickel-bronze, brass, mild steel and stainless steel. Of the four stainless-steel blades inserted, two were hardened and the other two hardened and tempered. The turbine with this experimental wheel was set to work in the autumn of 1916, and opened up for the first time in April, 1918, when all the blading was found to be in good condition, although the stainless-steel blades were the only ones entirely free from erosion or corrosion, the greatest sufferers being the brass blades.

Blades Unaffected by Service

The machine was again put into operation and re-examined last July, when it was found that the stainless-steel blades appeared to be absolutely unaffected by their service. It is worthy of note that the hardened and tempered blades were in as perfect a condition as the hardened blades. The

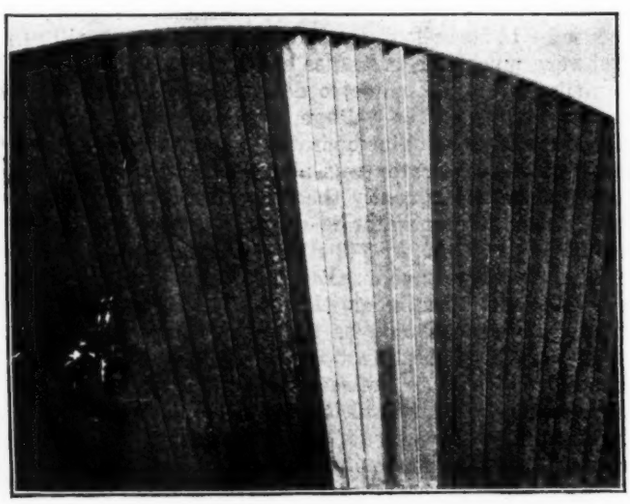


FIG. 1. SIX STAINLESS-STEEL BLADES IN LOW-PRESSURE STAGE AFTER 3,471 HOURS' OPERATION

phosphor-bronze, the nickel-bronze and the brass blades, on the other hand, showed the usual erosion at the inlet edges and to about the same extent in all cases. The mild-steel blades were not merely eroded, the inlet edge having lost one-sixteenth of an inch, but were also corroded generally, the surface being uniformly roughened. Mr. Samuelson, in experimenting with new materials, quite naturally preferred in the first instance to attempt no exceptionally drastic experiment and had accordingly selected for his trial a wheel in which the blading was short, the stresses low and vibration absent, so that his test, while demonstrating the resistance to corrosion of the stainless-steel blades, afforded no data for estimating the mechanical value of the material.

This lack has, however, been made good by another customer of Messrs. Firth & Sons, the makers of the steel, who

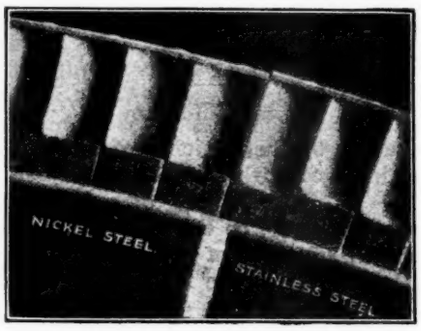


FIG. 2. STAINLESS-STEEL BLADES IN HIGH-PRESSURE STAGE AFTER 3,471 HOURS' OPERATION

some four or five years ago fitted into a turbine stainless-steel blades 28 in. long, and now reports that these blades have given entire satisfaction. Subsequently, Messrs. Firth themselves experimented with stainless-steel blades in one of the turbines at the power station of their Tinsley works, Sheffield. The machine selected for the test was a British Westinghouse impulse turbine, rated at 2,000 kw. and running at 3,000 r.p.m. This turbine was installed in 1916 and has been in almost constant use ever since, at loads ranging from full load down to one-quarter load. The steam supply is furnished at a pressure of 200 lb. per sq. in. (gage) and at a temperature that has averaged about 600 deg. F. The turbine in question has one velocity stage with two rows of moving blades with a mean diameter of 3 ft. 7½ in. followed by seven simple impulse stages, 4 ft. 1½ in. in mean diameter. The blading originally supplied to this turbine was of nickel steel containing 0.19 per cent of carbon and 4.71 per cent nickel.

The Messrs. Firth Begin Experiments

It was not till June, 1920, that Messrs. Firth were themselves able to take up Mr. Brearley's suggestion made in 1912, and began experiments of their own on the suitability of stainless steel for steam-turbine blading. On that date the turbine already described was opened up and experimental blades were fitted to two of the wheels, constituting the first, or velocity, stage of the turbine and the last stage, which is fed with wet steam. In the latter stage the blades are subject to the heaviest centrifugal and bending stresses. These blades are 7 in. long and ¾ in. wide, of the type shown in Fig. 1, while the velocity-wheel blading is shown in Fig. 2. Fig. 1 shows a portion of the wheel containing six blades of stainless steel, three being highly polished and the remaining three in the unpolished condition. On the opposite side of the wheel three more stainless-steel blades were inserted alongside of three new 5 per cent nickel-steel blades obtained from the builders of the turbine. In the velocity blading, a portion of which is shown in Fig. 2, 24 blades were replaced by 21 blades of stainless steel (three of which were polished) and by three new blades of 5 per cent nickel steel. These blades were

*Abstract of article entitled "Some Engineering Uses of Stainless Steel," published in the Oct. 28 issue of *Engineering*, London, England.

⅛ in. long by ¾ in. wide. The stainless steel used contained 13.4 per cent of chromium and 0.30 per cent of carbon.

The turbine was recently opened up after having operated 3,471 hours with the experimental blading. The stainless-steel blades appeared to be totally unaffected by the work done, as no corrosion and no erosion could be detected either by the eye or by touch. The inlet edges, where erosion is always most marked, were perfectly smooth, while those of the new nickel-steel blades inserted at the same time were materially roughened, and these blades had suffered corrosion. In the case of the nickel-steel blades originally fitted in 1916, the erosion was very noticeable, and the blades were deeply pitted and corroded. When the turbine was opened up, there were found to be some markings on the stainless steel, but these were easily removed with a damp rag, leaving a perfectly clear and smooth surface. These experiments seem to show that stainless steel is superior both to phosphor-bronze and to nickel-steel as a material for turbine blades.

Another interesting engineering application of stainless steel is to the rams of hydraulic pumps. A test pump supplying water at a pressure of 1,000 lb. per sq.in. has been at work since 1915. One of the rams is of stainless steel, and the other of phosphor-bronze. The stainless-steel ram has maintained its original polish much better and has worn down only $\frac{1}{64}$ in. as against $\frac{7}{64}$ for the phosphor-bronze.

All the experiments so far made with this material seem to indicate that it has great promise as an engineering material and will find many new uses. In this connection it should be noted that the methods of forging, heat treatment, etc., must be adapted to the special properties of stainless steel. As an example of the ways in which this alloy differs from ordinary carbon steel, it may be noted that stainless steel retains most of its strength up to a dull-red heat.

The American Society of Refrigerating Engineers

The seventeenth annual meeting of the American Society of Refrigerating Engineers was held at the Hotel Astor, New York City, Dec. 6 and 7.

The first day was taken up with the reading of the several committee reports and unfinished business. The election committee reported the election of Harry Sloan, Milwaukee, as president for the coming year.

G. A. Wegner presented a paper on the use of automatic temperature-controlled expansion valves. It was his opinion that these valves could be successfully used in the largest as well as in the smallest of plants. Where several coil temperatures are required, some form of temperature control is necessary.

Of special interest was the announcement that the Bureau of Standards would soon be in position to issue tables on superheated ammonia.

George A. Horne, New York City, read a paper on a test of a compound compressor. This is probably the most complete test ever made on a refrigeration plant. Considerable expense and some months time were spent in running the test and tabulating the results. Unfortunately, the paper is too long to reproduce in full. It was the author's opinion that intercooling by liquid ammonia was not economical and that water cooling was probably as effective as the usual combined water and ammonia cooling.

F. L. Fairbanks, Boston, gave the results of three tests conducted at the Quincy Market Cold Storage Co., covering a slow-speed steam-driven compressor with a booster set, a motor-driven compound compressor and a unaflow steam-engine-driven compound compressor with feather valves. In discussing the last-named unit, the author stated that early in 1920 it became necessary to increase (hurriedly, as usual) the plant capacity of the Quincy Market Cold Storage Co., Boston, Mass. It was decided to remove two of the old, slow-speed, single-acting, vertical compressors and two absorption machines, and to install at the Richmond Street Plant, in the space available, the most efficient type of steam-driven compressor obtainable.

A feather-valve compressor, horizontal, inclosed type, double acting, twin, tandem, two-stage, water intercooled, and driven by twin Stump unaflow engines, with a special variable-speed governor was selected.

The following data were collected during a preliminary test upon this unaflow unit. The author expects to better these considerably with a little preparation.

UNAFLOW STEAM-ENGINE-DRIVEN COMPRESSOR TEST DATA

Steam cylinders	19 in. by 24 in.
Compressor cylinders, l.p.	25 in. by 24 in.
Compressor cylinders, hp.	15 in. by 24 in.
Average speed during test	148 r.p.m.
Refrigeration produced = $\frac{1{,}700 \times 4.5 \times 8.33 \times 1.23 \times 0.706}{200}$	277 ton
Coefficient of performance of unit = $\frac{277 \times 12{,}000}{413 \times 2{,}545}$	3.16
Suction pressure at coolers, lb. per sq.in. gage	3½
Suction pressure at l.p. cylinder, lb. per sq in. gage	0
Suction temperature to l.p. cylinder, deg. F.	8
Discharge pressure, l.p. cylinder to intercooler, lb. per sq.in. gage	32
Discharge temperature l.p. cylinder to intercooler, deg. F.	150
Discharge pressure, intercooler to hp. cylinder, lb. per sq.in. gage	32
Discharge temperature, intercooler to hp. cylinder, deg. F.	66
Discharge pressure, hp. cylinder, lb. per sq.in. gage	129
Discharge temperature hp. cylinder, deg. F.	210
Average temperature of water entering intercooler, deg. F.	54½
Average temperature of water leaving intercooler, deg. F.	56½
Average temperature of water leaving ammonia condenser, deg. F.	62
Quantity of condensing water pumped, gal. per min.	1,000
Steam pressure, lb. per sq.in. gage	140
Superheat, deg. F.	125
Total steam temperature, deg. F.	485
Vacuum, inches	28
Brine temperature, entering cooler, deg. F.	4
Brine temperature, leaving cooler, deg. F.	8½
Brine pumped, gal per min.	1,700
Specific gravity of brine at 60 deg. F.	1.230

Other papers read at the second day's meeting were "Natural Ice, Artificially Produced," by R. H. Hemphill, Charleston S. C.; "Application of Synchronous Motors to Compressors," by Paul McCarty, East Pittsburgh, Pa.; "Starterless Induction Motors," by J. Lobovice, Cincinnati, Ohio.

On Wednesday the session was devoted to a discussion on Spray-Nozzle Cooling by B. H. Coffey and G. E. Dauphinee, New York, and Refrigerating Fluids by John E. Stair, New York. H. J. Macintire, Urbana, presented a new Pressure Total Heat Diagram for Carbon Dioxide.

One Cause of High Fuel Costs

In any business it makes little difference what percentage of the product produced can be delivered to the customer, the latter pays for all the production in any circumstances. In other words, waste in production or distribution is a charge against the user.

This is strikingly illustrated in a recent report on gas-supply conditions in Texas. It has been demonstrated by careful investigation that the amount of natural gas lost in the distributing plants within city limits, above what might be termed normal leakage for such systems, is more than equivalent to the entire production of manufactured gas in that state. It represents in these few cities, supplied from a single pipe-line system, the equivalent of more than four billion cubic feet of manufactured gas per year, which would have a money value at the average price of such manufactured gas of over $5,000,000.

As an indication of the efforts that are being made to find work for those who need it, the Washington Unemployment Conference has announced that out of the 327 cities in the United States of a population of over 20,000, Mayor's Emergency Committees have been organized by 209, as recommended by the conference, or have declared their ability to handle the problem with existing machinery. In many cities where committees have not been organized, there is no grave local problem. It is thought, therefore, that preparations are well under way for meeting the crisis of unemployment that is expected to occur in January or February. The situation is expected to be most troublesome in the States of New York, Pennsylvania, New Jersey, Ohio, Rhode Island and Texas.

Locating Baffles*

In designing horizontal baffles, the tendency is to make them too short in order to provide sufficient area of gas passage between their ends and the headers. Measurements of the drafts and velocities in the passes and between the baffles show that the gases pass very close to the ends of the baffles, so that most of the space between the ends and the headers is useless. The same thing is shown by baffles placed in a wide shallow stream of water. By placing oil upon the water, it will be plainly seen that the water passes close to the ends of the baffles and the water in the remaining space is stagnant.

In horizontal baffling the lowest baffle should always be on the bottom row of tubes, for otherwise there will be tube surface under the baffle, which is inactive and useless. Similarly, the highest baffle should be on top of the highest row of tubes instead of under them, in order to render these tubes efficient. The lowest baffle should always be in contact with the front header, for if not, any air that enters the firedoor of hand-fired boilers passes up in contact with that header, cools the boiler and does not support combustion. This is true to some extent when stokers are used, for the hopper may not be full of coal, thus giving air passage, and when it is, the air passes through the interstices of the coal above the combustion level. Boilers with vertical baffles always have this defect, and this is another reason for preferring horizontal baffles.

By making the baffles longer, the gases are compelled to sweep over more of the tube surface, and this increases the economy and adds somewhat to the forcing capacity of the boiler. By the latter it is meant that the economy is well maintained when the fuel consumption is increased well beyond the intended rate; in other words, the efficiency curve is straighter than in the case of a boiler with short baffles.

Still further, the economy and forcing capacity are improved by increasing the number of baffles, and thus the number of passes, and the number should be made as great as is consistent with a practicable loss in draft, for the greater the number of passes the greater is this loss. Many boilers with horizontal baffles have only one at the bottom and one at the top, but such boilers would be more efficient if more baffles were used. If it were possible, it would be best to have a baffle on every layer of tubes, but the draft absorption would be too great and cleaning impossible.

Things One Ought To Know About Government Publications

Many do not realize how great a mass of useful information may be found in the numerous publications of the Government. Probably the chief reason for this is that the Government's production of printed matter is so voluminous. One is inclined to think that trying to find official literature on any given subject is like looking for a needle in a haystack. Therefore, a few suggestions will be in order as to the best method of finding and securing Government publications.

In the first place, it should be remembered that the Superintendent of Documents, Washington, D. C., is the one to whom requests for information and orders for printed matter should be sent. He is authorized to sell at the cost of paper and printing any United States public document in his charge, the distribution of which is not otherwise provided for. Matter that is distributed free, however, may generally be obtained from the department, bureau or division by which it is issued. Often there is a limited free edition, only one copy being sent to each person until the supply is exhausted, after which copies may be bought from the Superintendent of Documents.

In writing to the Superintendent of Documents, whether to order a document or to inquire about one, give, if possible, the name of the department, bureau or division by which the literature was published, and, of course, the title. If the publication is numbered, give the number also, as this will save time. In remitting, remember that postage stamps will not be accepted nor will imperfect coins or foreign money. Currency may be sent, but of course that is risky. Approved methods are postal or express money orders, New York drafts or coupons. These coupons are sold by the Superintendent of Documents in sets of 20 for $1 and are good until used in exchange for Government publications. Postage to this country and its possessions is free, but to foreign countries, one-third the price of the document is required for postage.

*From a paper by F. W. Dean before the New England Water Works Association.

Catalogue of Documents

Those who wish to be informed as to Government publications regularly, should subscribe to the *Monthly Catalogue, United States Public Documents*, which is issued at a price of 50c. per year. This includes an index, which is issued at the end of the fiscal year and covers all matter published between July and June. No general catalog of Government publications is available (it would probably rival the dictionary in size), but lists on special subjects will be sent on application to the Superintendent of Documents.

One of the best-known current publications of the Government used to be the *Daily Consular and Trade Reports*, which appeared in the form of small pamphlets. In these were given miscellaneous items of interest from consuls and trade investigators in all parts of the world. In the recent reorganization of the Department of Commerce, however, the daily reports were given up in favor of a more carefully edited weekly report, which now appears in the form of a regular magazine, of about the same size as *Power*, with about 65 pages. It has been possible to departmentalize this publication and to give reviews of the existing situation in the various fields covered. These weekly reports are, of course, of direct interest only to those whose business is in some way related to foreign trade. The subscription price is $3 a year.

Survey of Current Business

Another new undertaking of the department, which was accomplished about a month before the change in the commerce reports, is the monthly *Survey of Current Business*. The object is to give an up-to-date bird's-eye view of industry as a whole and of separate industries. The survey is the cream of the department's fund of information. It contains a truly astonishing amount of material, which is all in the form of condensed summaries rather than long, meaningless lists. The subscription price is $1 a year, and single copies can be obtained for 10c.

Of especial interest to *Power's* readers, of course, are the monthly report on the "Production of Electric Power and Consumption of Fuel by Public Utility Power Plants in the United States," and the weekly report on the "Production of Bituminous coal, Anthracite and Beehive Coke," both issued free by the Geological Survey.

For a bird's-eye view of the Government's activities in the publishing line, Swanton's "Guide to United States Government Publications" will be found helpful. It is Bureau of Education Bulletin, 1918, No. 2, and may be had for 20c. from the Superintendent of Documents. Information may also be obtained from officials of public libraries, who can often give valuable suggestions.

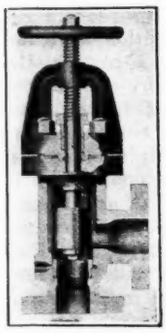
Swedish and American engineers will make an effort to draw their respective countries closer together on March 9, 1922, when the sixtieth anniversary of the battle of the Monitor and Merrimac will be celebrated simultaneously in Stockholm, Sweden, and New York and Washington. The DeLamater-Ericsson Tablet Committee of the A. S. M. E., headed by H. F. J. Porter, which is making arrangements for the American celebration, has announced that word has been received of the Swedish plans from the Association of Swedish Engineers.

The Tenth Midwinter Convention of the American Institute of Electrical Engineers, which is to be held Feb. 15-17, 1922, in New York City, will be the first meeting of the year under the new policy of the Institute prescribing four general meetings for each year including the annual convention.

Condensed-Clipping Index of Equipment

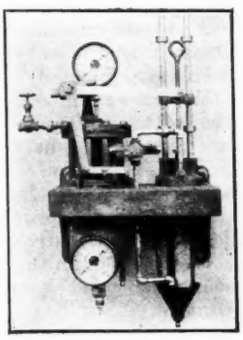
Patented Aug. 20, 1918

Valve, Faber Self-Cleaning Blowoff
Elliott Co., Jeannete, Pa.
"Power," 1921



This redesigned Faber blowoff valve, although retaining old features, has new ones, in that the difficulty encountered with the accumulation of scale and sediment on the top of the piston is eliminated, for as the valve is opened, a circulation of water is set up around and over the top of the piston, through channels in the valve body, thus thoroughly cleansing the top of the piston when in the act of opening the valve. When the valve is closed sufficiently, water from the boiler is practically shut off, and the steam entering through a ¼-in. opening cleanses the valve seat and disc of sediment just before the valve is finally seated. The valve is made in two types, for 250 lb. and 500 lb. working pressure. It is made only in the flanged type in 2-in. and 2½-in. sizes.

Control, Gradeca Combustion
J. M. Wilson, 1036 Arlington Ave., S.W., Canton, Ohio.
"Power," July 26, 1921.

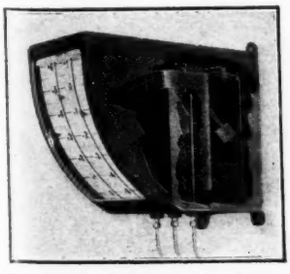


A draft regulator designed to move the damper through a greater distance at the beginning of a pressure rise and to slow down gradually as the stroke of the machine progresses, so that furnace conditions are controlled with the least possible amount of disturbance, yet with sufficient effect for the purpose. With a dropping pressure the action is reversed and the fire is gradually increased in intensity, an adjustment is provided which compensates for any slight change in air pressure and also enables the damper to be moved to any part of the stroke for operating purposes, and then returned to its original position for any prearranged pressure.

Switch, Turbine Tripping
General Electric Co., Schenectady, N. Y.
"Power," 1921.

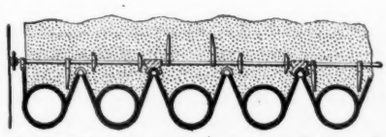
Safe and successful operation of steam-turbine generator sets has been aided through the recent development of a turbine trip switch which provides an automatic means of signaling the operator at the switchboard when the throttle valve is tripped, by overspeed, vibration or other emergency. In some instances considerable damage has occurred, due to turbines being allowed to motor, with consequent overheating, after the steam was shut off. The switch is actuated by the last ¼-in. motion of the throttle valve stem and may be arranged so as to set off automatically an audible or other form of alarm signal at the switchboard or, if connected to the main generator switch, to disconnect the turbine from the line automatically.

Gage, Bailey Multi-Pointer Draft
Bailey Meter Co., Cleveland, Ohio.
"Power," Nov. 1, 1921.



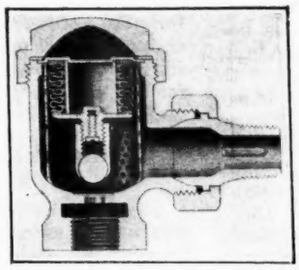
This meter has a pointer that has a 10-in. motion along the arc of an illuminated scale. The gage can be made in sizes to accommodate from two to twelve pointers. The draft is connected to a standpipe in the oilseal bell, which is balanced by a counter rod at the opposite end of the beam. The draft suction lifts the oil within the bell and draws the bell deeper into the oil. This force is balanced by a pendulum placed between the bell and counterweight, and is moved horizontally and thereby introduces a movement of force that balances the force due to the draft suction on the bell. The draft pressure may vary from a maximum 0 to 7 in. of water to a minimum of 0 to 0.10 in. for the full pointer motion of 10 in. Each gage reads directly and is labeled to show with what it is connected.

Agitator, J. C. Casler
Casler Engineering Co., 150 Nassau St., New York City
"Power," 1921.



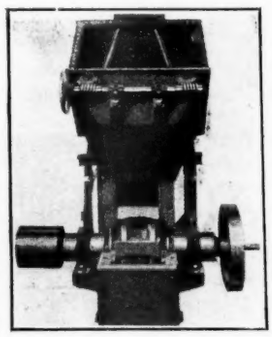
This agitator is designed primarily to overcome the difficulties encountered with wet coal feeding down in the hoppers of underfeed stokers and of making positive the feeding of wet fuel, thus eliminating the labor employed in poking down the coal. The agitator shaft is made in sections corresponding in length to each section of the stoker crankshaft, and the agitator fingers are so timed that the arching coal is broken down when the plungers are in a position to receive the full charge of coal on any one section. A shearing pin is arranged on the sprocket of the agitator shaft to provide for safety.

Trap, Sarco Radiator
Sarco Co., Inc., Woolworth Bldg., New York City.
"Power," 1921.



The thermostatic element of this trap comprises a spiral corrugated tube in which is contained a volatile fluid. Steam entering from the radiator heats the element and causes the center fluid to vaporize. This releases the vacuum within the element and continually builds up pressure, expanding the tube and removing the valve downward to its seat. When sufficient condensation has drained through the trap, the element cools and the gas returns to a liquid state. The vacuum re-forming, contracts the element and opens the valve, whereupon all water and air are discharged to the return. Steam, following immediately, closes the valve again.

Pulverburner, The
K-B Pulverizer Co., Inc., 92 Lafayette St., New York City.
"Power," 1921.



The pulverburner consists of a pulverizing machine and air-separating chamber automatically fed from an overhead storage bin and delivering finely powdered fuel by a fan blast through suitable pipings to the combustion chamber of the boiler setting. Coal is fed to the pulverizer at any desired rate of speed, and is crushed by revolving hammers against breaking blocks and is thrown by centrifugal force into the separating chamber. Air drawn through the chamber at low velocity by the fan carries away the fine coal and allows the coarse coal to return to the machine for further pulverizing. The fine coal is drawn through the fan and delivered to the nozzle, or it can be diverted into several streams to serve several nozzles.

Cableway, Harrington Rocking
Railway and Industrial Engineering Co., Greensville, Pa.
"Power," 1921

This cableway consists of a balanced rocking tower or train which enables the device to provide an improved cableway for crane service over storage yards. A tower is placed at each end of the cableway and they rock in unison so that the main track cable is transferred laterally. It is operated either by steam or electricity and requires but one operator. In operation the bucket picks up its load of coal and the towers are rocked in the direction required, so that the bucket can be moved to a point over the conveyor hopper where the fuel is dumped. The towers are then rocked back in place over the coal pile, and the operation is repeated.

Clip, paste on 3 x 5-in. cards and file as desired

News in the Field of Power

Advertising Bulletin Out

Announcement has been received from the Engineering Advertisers' Association of Chicago of publication of its new monthly bulletin, which contains digests of speeches, personal notes and other information of value to advertising managers of technical or engineering firms, to whom it will be sent on request. The current copy gives an address by Kenneth Groesbeck, of the Harry Porter Co., of New York City, on "The Baconian Theory of Advertising."

Westinghouse Co. Competing with the Movies

A plan of covering the entire country with a radio service that will transmit news and musical selections to homes all over the United States has been announced by the Westinghouse Co., which for the past year has been carrying out the idea in the first radio broadcasting station of its kind in the country, at East Pittsburgh. It is said that such stars as Geraldine Farrar, Rachmaninoff, Mary Garden, etc., have performed for the radio, as well as many speakers of note, including Secretaries Hoover, Weeks and Davis.

The programs, which are announced beforehand, last for an hour each evening, and it is felt that eventually radio will become as popular in the home as the phonograph is today, and as interesting to the public as the movies.

In carrying out its plan the company has already added three large stations: at Springfield, Mass., Newark, N. J., and Chicago, in addition to the pioneer plant at East Pittsburgh.

Foch Honored by Engineering Societies

Honorary membership in the four national engineering societies—American Society of Mechanical Engineers, American Society of Civil Engineers, American Institute of Electrical Engineers and the American Institute of Mining and Metallurgical Engineers—was conferred upon Marshal Foch last Tuesday afternoon, before a large assemblage in the Engineering Societies Building, New York City.

J. V. Davies, president of the United Engineering Societies, presided and introduced Col. W. B. Parsons, who delivered an address of welcome to the Marshal. "You Marshal," he said, "have directed a greater mass of human energy than any other man has ever done. And you have successfully directed this mass for the highest uses of mankind. Of all the sources of power in nature, the greatest, the most valuable, and at the same time the most difficult to direct, is the energy of man himself. He who can direct human energy and turn it to the service of mankind is a great engineer." Col. Parsons also brought out the fact that four thousand members of these societies had been enrolled in the armed service of the United States, the greater part of whom had the distinction of serving the common cause in France under the Marshal's orders.

George S. Webster, president of the American Society of Civil Engineers, then presented the Marshal with the certificates of honorary membership. In accepting the honor, Marshal Foch paid the highest tribute to the service of the engineers in winning the war. "What would have become of the army without the engineer?" he asked. "What would have become of it without the technical knowledge of the engineering profession? Without these engineering elements," Marshal Foch added, "it would not have been possible for the armies to have been led, fed and protected on the battlefield. The science of engineering made it possible for the soldiers to advance quickly and decisively."

Vocational Educators to Meet in Kansas City

The National Society for Vocational Education has announced the complete program for its coming annual convention at Kansas City, Mo., Jan. 5-7, 1922. The affair will include general meetings, round-table conferences, a banquet, sectional meetings and a number of exhibits.

The sectional meetings, each of which will last two days, will cover eight subjects: Agricultural Education, Commercial Education, Home-making Education, Industrial Education, Part Time and Continuation Schools, Teacher Training, Training in Industry and Industrial Rehabilitation.

Visitors to the convention have been invited to spend Jan. 4 at the University of Missouri, where a number of courses are of interest in vocational work. Features of the convention will include an exhibit of valuable unpublished matter on vocational education and motion pictures that are used to teach shop processes. A single convention fee of $2 will be charged. Half-fare on the return trip will be secured from the railroads if 350 visitors apply for it. The national headquarters are at 140 West 42d St., New York City.

A Get-Together Lunch in a Boiler Firebox

To promote a friendly feeling on the part of its customers and neighbors, the New York Steam Corporation recently adopted the unique idea of inviting some of them to a luncheon party in the furnace of one of the new 12,660-sq.ft. boilers now being put up at the Fifty-ninth Street Station. It is understood that a wealthy residential colony, which had suddenly sprung up close to the plant, had made strong objections to the soot deposited on their residences whenever the wind came from the heating station.

Not to be left behind in the prevailing tendency toward peacefulness, the company proceeded to install the necessary apparatus to keep the cinders from wandering astray, and then invited the objectors in for a good luncheon and an inspection of the plant. That the affair had the desired results is indicated by the diners' expressions, as shown in the accompanying photograph.

AN UNUSUAL PLACE FOR A LUNCHEON

Personals

Julian C. Smith, vice president of the Shawinigan Water and Power Co., is supervising construction of the Great Falls power plant of the Manitoba Power Co.

L. B. Winton, formerly in the mechanical engineering division of Stone & Webster and for a time with the New York Steam Co., has been appointed works manager of the Stanley Insulating Co., Great Barrington, Mass.

John J. Reddy of Jersey City, N. J., well known in N. A. S. E. circles as state deputy of New Jersey, has taken a position with the sales department of the Tide Water Oil Co., of Bayonne, N. J. Mr. Reddy will represent the company in the central part of New Jersey.

Charles H. Bromley, formerly technical director of the Richardson-Phenix Co., Milwaukee, Wis., has become manager and chief engineer of the newly formed Richardson-Phenix Division of S. F. Bowser & Company, Inc. This division is to conduct the filtration and lubrication-appliance business of the consolidated companies, with the main office at Fort Wayne, Ind. Mr. Bromley was associate editor of *Power* before joining the Richardson-Phenix Co. late in 1920.

E. H. Seaman has resigned as chief engineer of the survey and engineering department of Johnson & Higgins, to take charge of the advisory and engineering department of Alfred M. Best Co., 73 Fulton St., New York City. He will direct operations in the Eastern and Southern fields, devoting especial attention to the reduction of waste and cost of insurance in industrial plants, his company being a service organization.

Society Affairs

Atlanta Section, A. I. E. E., is to meet Dec. 29 to hear a timely discussion of "Muscle Shoals," by C. G. Adsit, vice president of the society.

Colorado Section, A. S. M. E., will hear a talk by Prof. J. L. Morse, of the Colorado School of Mines, on the "Development and Modern Application of the Internal Combustion Motor," at the Metropole Hotel, Denver, Dec. 30.

Business Items

The Maher Engineering Co., 30 North Michigan Blvd., Chicago, has appointed C. B. Adams vice president and sales manager, and C. H. Peterson secretary-treasurer and general manager.

The Barnhart-Davis Co., Irvine St., Warren, Pa., has appointed as vice president and general manager, A. A. Albaugh, formerly general superintendent of the Jacobson Machine Manufacturing Co.

The Atlas Valve Co., 282 South St., Newark, N. J., is now represented in Chicago and Detroit through the Maher Engineering Co. The Detroit office is at 744 David Whitney Building and the Chicago office at 30 North Michigan Blvd., in charge of E. E. Maher.

The Betson Plastic Fire Brick Co., Rome, N. Y., has put C. Z. Dillenbeck in charge of the Chicago office at 1514 Kimball Building. L. S. Shaw & Co., 5716 Euclid Ave., Cleveland, are to act as general agents and distributors in Michigan, Ohio, Indiana and Kentucky.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Dec. 5, 1921	Dec. 12, 1921
Pool 1,	New York	$3 00	$2.75@3.25
Pocahontas	Columbus	2.25	2.10@2.30
Clearfield	Boston	1.80	1.60@2.00
Somerset	Boston	1.85	1.65@2.00
Pittsburgh	Pittsburgh	2.15	2.10@2.20
Kanawha	Columbus	1.90	1.80@1.95
Hocking	Columbus	1.95	1.90@2.00
Pittsburgh No. 8	Cleveland	2.00	2.00@2.10
Franklin, Ill.	Chicago	2.75	2.5 \@3.00
Central, Ill.	Chicago	2.25	2.25@2.75
Ind. 4th Vein	Chicago	2.75	2.60@2.90
Standard	St. Louis	1.95	1.90@2.00
West Ky.	Louisville	1.75	1.50@2.00
Big Seam	Birmingham	2.00	1.50@2.50
S. E. Ky.	Louisville	2.05	1.65@1.85

New York—On Dec. 14 Port Arthur light oil 22@25 deg. Baumé, 5c. per gal. 30@35 deg., 6c. per gal., f.o.b. Bayonne, N. J.

Chicago—Dec. 10, for 24@28 deg. Baumé, 80@85c. per bbl.; 32@36 deg., 2¾@3c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Dec. 13, f.o.b. refinery, Pennsylvania, 36@40 deg., 5@5¼c. Oklahoma, 24@30 deg., 95c. per bbl.; gas oil, 32@34 deg., 2½@2¾c. per gal.; 34@36 deg., 3¼c., 38@40 deg., 3½c. per gal.

St. Louis — Dec. 10, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 80c. per bbl.; 26@28 deg., 90c.; 28@30 deg., $1; 32@34 deg., 2¼c. per gal.

Philadelphia — On Dec. 12, 26@28 deg. Baumé, Oklahoma, 90c.@95c. per bbl.; 30@34 deg., Oklahoma (group 3), 2¾@3c. per gal.; 16@20 deg., Seaboard, 90c.@$1 per bbl.

Cincinnati — Dec. 6, for 26@34 deg. Baumé, 4½c.; Diesel 34@36 deg., 5c. per gal.; distillate 38@40 deg., 5½@6c. per gal.

Cleveland—Dec. 6, for 26@34 deg. Baumé, 3¾c. per gal.

New Construction

PROPOSED WORK

Conn., Newington—The Connecticut Children's Aid Society, 926 Main St., Hartford, is having plans prepared for a home including dormitories, school, hospital and nurses buildings. About $600,000. I. A. Allen, Jr., Inc., 904 Main St., Hartford.

Conn., Windsor—The Farmington River Power Co., Poquonock St., c/o E. W. Pelton, is having plans prepared for a power plant consisting of 4 units having a capacity of 12,000 hp. also a dam about 1,000 ft. long. I. W. Jones, Milton, N. H., engr.

N. Y., East Rochester — The Merchants Dispatch Transportation Co., manufacturers of railroad cars, is in the market for a plate heating furnace of Progressive type, and 2 modern type air compressors with 450 hp. motors, also other car shop machinery.

N. Y., New York—The Jewish Orphanage Asylum, Amsterdam Ave. and 138th St., has had plans prepared for an orphanage on 233rd St. between Baychester Ave. and Boston Post Rd. About $500,000. E. Necarsulmer, 507 5th Ave., Archt., Tenny & Ohmer, 101 Park Ave., Engrs.

N. Y., New York — The United States Ferro Alloys Corp., 30 East 42nd St., N. Petinol, Purch. Agt., is in the market for an air compressor, gasoline driven, 5 to 75 cu.ft. per minute 100 lb. pressure.

N. J., Bayonne — The Bd. Educ., 651 Bway., is having preliminary plans prepared for a 3 story, 200 x 300 ft. junior high school on Ave. A at 27th to 29th Sts. About $450,000. D. G. Anderson, 472 Bway., Archt.

N. J., Nutley—The Bd. Educ., will soon receive bids for a high school including a steam heating system. About $400,000. Starrett & Van Vleck, 8 West 40th St., New York City, Archts. and Engrs. Noted Feb. 22.

N. J., Secaucus (Weehawken P. O.)—The Bd. Freeholders, W. O'Mara, Courthouse, Jersey City, will receive bids until Dec. 22 for a 2 story insane asylum consisting of several bldgs. including a power plant on County Rd. About $700,000. J. T. Rowland, Jr., 100 Sip Ave., Jersey City, Archt.

Pa., Pittsburgh—The Bd. Educ., G. W. Gereig, Secy., Fulton Bldg., is having plans prepared for a 2 story, 87 x 303 ft. high school on Charteers, Hutton and Robina Sts. About $500,000. McCure & Spahr, Keystone Bldg., Archts.

Md., Baltimore — Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., will receive bids until Dec. 27 for the installation of a lighting plant, etc., at the United States Quarantine Station, here.

Ga., Augusta—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., plans the construction of a United States Public Health Service Hospital here. About $600,000.

Ala., Tuskegee — Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., plans the construction of a United States Public Health Service Hospital here. About $2,500,000.

Miss., Belzoni—The Belzoni Drainage District plans to install a pumping plant for the reclamation of about 4,000 acres of land.

Ky., Louisville — R. C. Whayne Supply Co., 608 West Jefferson St., is in the market for a portable air compressor, 200 to 300 cu.ft. per min., 100 lbs. pressure, either gasoline engine driven or 250 volt., D. C., electric motor.

O., Chagrin Falls — The Orange Rural School District, c/o T. W. Taylor, Clk., is having plans prepared for a 2 story high and grade school and boiler house. About $200,000. C. W. Bates, 77 12th St., Wheeling, W. Va., Archt.

O., Cleveland—The city received bids for 4 water tube boilers for Division of Water from Babcock & Wilcox Co., Guardian Bldg., $91,834; D. Connelly Boiler Co., Ivanhoe Rd., $99,100. Low bidder for stokers, Ford Reily Co., 1836 Euclid Ave., $42,490. Noted Dec. 6.

Ind., Fort Wayne — The Consolidated Realty & Theatres Corp., 401 Physicians Defense Bldg., is having plans prepared for a 6 story, 150 x 190 ft. theatre and hotel on Wayne St. About $1,250,000. J. E. D. Pridmore and F. E. Fowler, care of owners, Archts.

Ind., Indianapolis—F. R. Chandler, 3817 North Pennsylvania St., is having plans prepared for a 5 story, 60 x 202 ft. garage at 30-32 West Vermont St. About $250,000. Vonnegut, Bohn & Mueller, 610 Indianapolis Trust Bldg., Archts.

Ind., Indianapolis—The Mutual Milk Co., Minnesota and Bethel Aves., is having plans prepared for a 1 story, 40 x 67 ft. power plant and warehouse. About $25,000. E. Crabb, 1112 State Life Bldg., Archt.

Ind., Indianapolis — E. G. Spink Co., Hume-Mansur Bldg., is having plans prepared for a 6 story, 52 x 178 ft. apartment hotel on North Pennsylvania St. About $450,000. W. K. Eldridge, care of owner, Archt.

Ind., Kokomo—J. M. Leach Co., 305 South Main St., is having plans prepared for a 1 story, 30 x 40 ft. power plant. About $25,000. T. McGaw, Citizens Bank Bldg., Archt.

Ind., Laporte — The Bd. School Comrs. plans to build a 2 story high school. About $500,000. Architect not selected.

Ind., Michigan City — The Haskell & Barker Car Co., will soon award the contract for a 1 story power plant and foundry on 4th and Wabash Sts. About $500,000. F. D. Chase, Inc., 545 North Michigan Ave., Chicago, Ill., Engr.

Ind., South Bend — The city is having plans prepared for a 1 story, 20 x 50 ft. water power station. About $45,000. W. Artingsall, 37 West Van Buren St., Chicago, Ill., Engr.

Mich., Springville—The council is having plans prepared for a sewer system including a pumping station, electrically driven centrifugal pumps for pumping sewage, etc. Total cost, $1,250,000. A. Roth, Village Engr., and C. W. Hubbell, Consulting Engr., 2348 Penobscot Bldg., Detroit.

Ill., Chicago — The Normand Cushion Wheel Co., 818-32 South May St., is having plans prepared for a 2 story factory including a steam heating system on Western and 77th Sts. About $500,000. J. L. Mrazek, care of owner, Archt.

Ill., Chicago—M. F. Schiavone & General Realty Co., c/o Whitney & Williams, Archts., 110 South Michigan Ave., are having plans prepared for a 4 story, 120 x 250 ft. theatre including a steam heating system on Howard St. and Marshfield Ave. About $3,000,000.

Ill., Chicago — H. H. Windsor, c/o Marshall & Fox, Archts., 712 North Michigan Ave., is having plans prepared for a 7 story, 100 x 125 ft. publishing plant including a steam heating system on Ontario and St. Clair Sts. About $400,000.

Ill., Chicago — J. Zolton, 2317 South Wabash Ave., is in the market for an air compressor 18 to 21 cu.ft. capacity.

Wis., Fond-du-Lac—The Eastern Wisconsin Electric Co., 15 North Main St., B. W. Arnold, Mgr., is in the market for equipment and machinery for electric substation. Motors, generators and electric machines for transforming current from Sheboygan, from A.C. to D.C.

Wis., Green Bay—The Investment Corp., of Green Bay, L. M. Hansen, Pres., 113 West Walnut St., will receive bids about Jan. 10 for a 3 story, 80 x 240 ft. cold storage plant on North Broadway. About $250,000. Private plans. Two ice machines will be installed.

Wis., Milwaukee—Lockwood Green & Co., Archts., 38 South Dearborn St., Chicago, Ill., is receiving bids for a 3 story, 260 x 315 ft. tannery at 658 Commerce St. for the Amer. Hide & Leather Co., 1320 Elston St., Chicago, Ill. About $500,000. Tanning machinery, power plant equipment, coal and ash handling machinery, boilers, etc., will be installed. G. A. Riker, Mgr. of Milwaukee plant. Noted Nov. 1.

Wis., Rhinelander—The S. Miller Fruit Co., is having plans prepared for a 3 story, 53 x 126 ft. warehouse and cold storage plant. About $150,000. Private plans. Artificial ice making machinery will be installed. Noted Nov. 22.

Wis., Wisconsin Rapids — The Consolidated Water Power Co., J. Schnabel, Purch. Agt., is receiving bids for equipment for pulp storage bldg., including conveyor for handling shredded pulp, buckets, etc., also blowers for heating system. L. A. DeGuere, Wisconsin Rapids, Engr.

Ia., Corning—The city will receive bids until Jan. 15 for a municipal power plant. About $60,000. C. K. Munns, Engr. Noted July 26.

Minn., Morris—The city, F. J. Haight, City Mgr., will receive bids until Dec. 27 for new filtration plant, settling basin and aerator, also installation of filters and pump equipment. About $16,000. C. F. Tweed, 531 Metropolitan Bank Bldg., Minneapolis, Engr.

Kan., Independence—The Bd. Educ. will soon award the contract for a 2 story junior high school including a 79 x 40 ft. boiler house and 100 x 54 ft. smoke stack. About $500,000. N. S. Spencer & Son, 37 West Van Buren St., Archts.

Neb., Lincoln—The city, T. H. Berg, Clk., will receive bids until Jan. 4 for furnishing and erecting on foundations furnished by city, one 2,500 k.w. turbo generator with surface condenser, switchboard complete, 3 phase, 60 cycle, 4,400 volts. Steam pressure 150 lb. with 120 deg. superheat. About $75,000. G. W. Bates, Lincoln, Engr.

S. D., Watertown — The Public Utilities Comn., A. J. Mueller, Supt. electric light plant will receive bids until Jan. 12 for an electric light plant and complete distribution system. About $40,000

N. D., Devils Lake—The Midwest Power Co., Hackney Bldg., St. Paul, Minn., A. H. Savage, Pres., plans to build a 1 story, 40 x 40 ft. addition to power plant here, and install equipment including 250 kva. steam generating unit, condensing apparatus and new cooling basin. About $40,000.

Wyo., Greybull—The Greybull Irrigation Dist., c/o S. Skovard, Basin, is having plans prepared for the construction of a dam on Sunshine Creek to impound 50,000 acre. ft. of water and supply canal from Greybull River to the reservoir. About $800,000. J. B. True, Cheyenne, Engr., and F. G. Carpentier, First Natl. Bank Bldg., Denver Col., Consulting Engr.

Mo., Excelsior Springs—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., will receive bids until Dec. 23 for the heating equipment for the boiler house, outside services and connections to building at the United States Public Health Service Hospital, here.

Mo., Kansas City—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., plans the construction of a United States Public Health Service Hospital here. About $2,000,000.

Mo., St. Louis—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C. plans the construction of a United States Public Health Service Hospital here. About $500,000.

Tex., Dallas—M. G. James, City Secy., will receive bids until Dec. 30 for a 3 story, 30 x 130 ft. hospital on Oak Lawn St. and Maple Ave. About $300,000. H. M. Greene Co., North Texas Bldg., Archt.

Cal., Sacramento — The Sacramento-San Joaquin Bank is having plans prepared for an 18 story bank and office building on 7th and K Sts. About $1,250,000. Weeks & Day, Phelan Bldg., San Francisco, Archts. and Engrs.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Dec. 28 for the installation of gas, water, sewer, and an underground electric system. About $100,000. Spec. 4559. Noted Dec. 6.

Ont., Essex—The council considers modification of the equipment in its electrically operated pumping station with a view to reduction in operating cost. M. Gilboe, Supt.

Ont., Hamilton—The Bd. Educ. is receiving bids for a 2 story school including a steam heating system with mechanical ventilation on Main St. About $300,000. F. W. Warren, Home Bank Bldg., Archt.

Ont., Londesboro—The council, J. Fingland, plans an electric light and power distribution system for the township. About $40,000.

Ont., London—The Ontario Power Comn., A. Beck, Chn., plans a hydro-electric system to serve the towns of Tara, Port Elgin, Southampton and Paisley. About $100,000.

Ont., Penetang—Gropp Bros. plans to build their saw mill which was recently destroyed by fire. About $20,000. Prices wanted on machinery including boiler, engine, belting, etc.

Ont., Petrolea—The Council will soon receive bids for the installation of 2 electrically driven centrifugal pumps, 750,000 gal. serservoir, etc. About $42,000. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs. Noted Nov. 29.

Ont., St. Marys—The Township Council, J. H. Jameson, plans electric light and power distribution system for part of township. About $40,000.

Ont., Thedford—The council, G. Sutherland, is having surveys made for an electric light and power distribution system. About $30,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

Que., Verdum—The city, G. E. Ghyshans, City Engr., will receive bids until Dec. 22 for 2 electric driven pumps for water works.

CONTRACTS AWARDED

N. J., Glassboro — The State Comn. of Educ., State House, Trenton, has awarded the contract for a heating and ventilating system for the proposed 2 story normal school here, to the DuPont Engr. Co., Wilmington, Del., $47,270. Noted Nov. 29.

N. J., Passaic—The Passaic Valley Sewerage Comn. has awarded the contract for superstructure for Wallington Pumping station to H. S. Jones Building Co., Inc., 280 Madison Ave., New York City, $54,200.

Pa., Philadelphia—The Atlantic Refining Co., 1211 Chestnut St., has awarded the contract for a 21 story, 117 x 138 ft. office bldg. on Broad and Spruce Sts. to Metzger, Fisher & White, Otis Bldg. About $2,000,000. A steam heating system will be installed.

Pa., Turtle Creek—The Wilkinsburg Ice Co., 208 Centre Ave., Wilkinsburg, has awarded the contract for a 1 story, 85 x 106 ft. ice plant on Monroeville Rd. to E. Z. Peffer, 747 Hill St., Wilkinsburg. About $125,000.

Pa., Washington—The Tyler Pipe & Tube Co. has awarded the contract for a 1 story, 20 x 50 and 50 x 50 ft. boiler house and gas producer house to the Riverside Bridge Co., Washington. About $50,000. Noted Dec. 6.

O., Canton—The Bd. Educ., W. C. Lane, Clk., has awarded the contract for a 3 story, 144 x 226 ft. school on 6th St. to A. F. Wendling Co., Massillon, $431,000. Steam heating system will be installed. Noted Nov. 1.

O., Cincinnati—Gibson House Co., Walnut St., near 4th., has awarded the contract for a 14 story, 102 x 190 ft. hotel on 5th and Walnut Sts., to Wells Bros. Constr. Co., 427 Walnut St., $2,000,000. A steam heating system will be installed.

O., Rocky River—The Riverview Improvement Co., c/o B. Little, 3751 Prospect Ave., Cleveland, has awarded the contract for an 8 story, 55 x 340 ft. commercial and apartment hotel bldg. on Detroit Rd. to Crowell & Little Constr. Co., 3751 Prospect Ave., Cleveland. About $1,500,000. A steam heating system will be installed.

Mich., Detroit — The Bd. Fire Comrs., Larnes and Wayne Sts., has awarded the contract for furnishing and installing electrical equipment for high pressure pumping station including switchboards, etc. to Turner Engr. Co., 452 Larned St., $50,461. Noted Dec. 13.

Ill., Chicago—The Illinois Life Insurance Co., c/o Holabird & Roche, Archts., 104 South Michigan Ave., has awarded the contract for a 2 story, 118 x 125 ft. x 192 ft. office bldg., including steam heating system, at 1206-24 Lake Shore Drive to Avery Brundage, 110 South Dearborn St. About $500,000. Noted Sept. 6.

Ill., Chicago—The Nemo Dye Wks., c/o P. Gerhardt, Archt., 64 West Randolph St., has awarded the contract for a 1 story, 103 x 115 ft. factory at 4203-07 Grand Ave. to A. and E. Anderson, 19 South La Salle St. About $125,000. Contract for power plant to cost $75,000 will be awarded later. Noted Dec. 13.

Ill., Chicago—W. C. Reebie & Bro., 2531 Sheffield Ave. has awarded the contract for a 7 story, 168 x 190 ft. warehouse at 3925-29 North Clark St., to Ralph Sollit Sons Co., 30 North LaSalle St. About $400,000. A steam heating system will be installed.

Wis., Green Bay — The Fort Howard Paper Co., A. Cofrin, Mgr., has awarded the contract for a 3 story, 100 x 120 ft. paper mill and power house to L. M. Hansen Co., 113 West Walnut St. About $105,000.

Ia., Dubuque—The Globe Portland Cement Co. has awarded the contract for a 1 and 2 story cement plant consisting of 7 or 8 bldgs., cement storage tanks of 250,000 bbl. capacity, truckage, etc., to H. C. Struchen, 405 Dakota Bldg., St. Paul, Minn., 12,000,000.

Tex., Graham—The city has awarded the contract for waterworks and sewage plant to the James Contracing Co., Eastland, $133,000. Noted Nov. 15.

Tex., Kerrville — The American Legion Memorial Sanitarium, S. B. Cowell, Chn. Building Bd., Austin, has awarded the following contracts: construction of a 1 story infirmary bldg., a 1 story laundry, a 2 story nurses home to the McKenzie Constr. Co., 606 Bedell Bldg., San Antonio, $270,400; conduits and tunnels for steam pipes to the Elder Constr. Co., Moore Bldg., San Antonio, $26,370; outside piping and boiler house work to J. L. Martin, 406 Congress Ave., Austin, $53,571; boilers to Smith & Whitney, South West Life Bldg., Dallas, $23,280; steam heating to J. L. Martin, 406 Congress Ave., Austin, $9,294. Noted Nov. 29.

Wash., Walla Walla—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., has awarded the contract for the installation of mechanical equipment in the United States Public Health Service Hospital, to Bergh-Griggs Co., Tacoma, $121,375. Noted Nov. 1.

Cal., Sacramento—A. B. Atkinson, 3256 5th Ave., will build a 1 story, 80 x 160 ft. ice plant on 13th and S Sts. About $75,000. F. A. S. Foale, Ochsner Bldg., Archt. Owner will build by separate contracts.

Cal., San Francisco—The Bd. Public Wks. has awarded the contract for a heating and ventilating system to be installed in the proposed Mission high school on 18th St., between Dolores and Church Sts., to J. Nelson, 517 6th St., $37,697. Noted Nov. 8.